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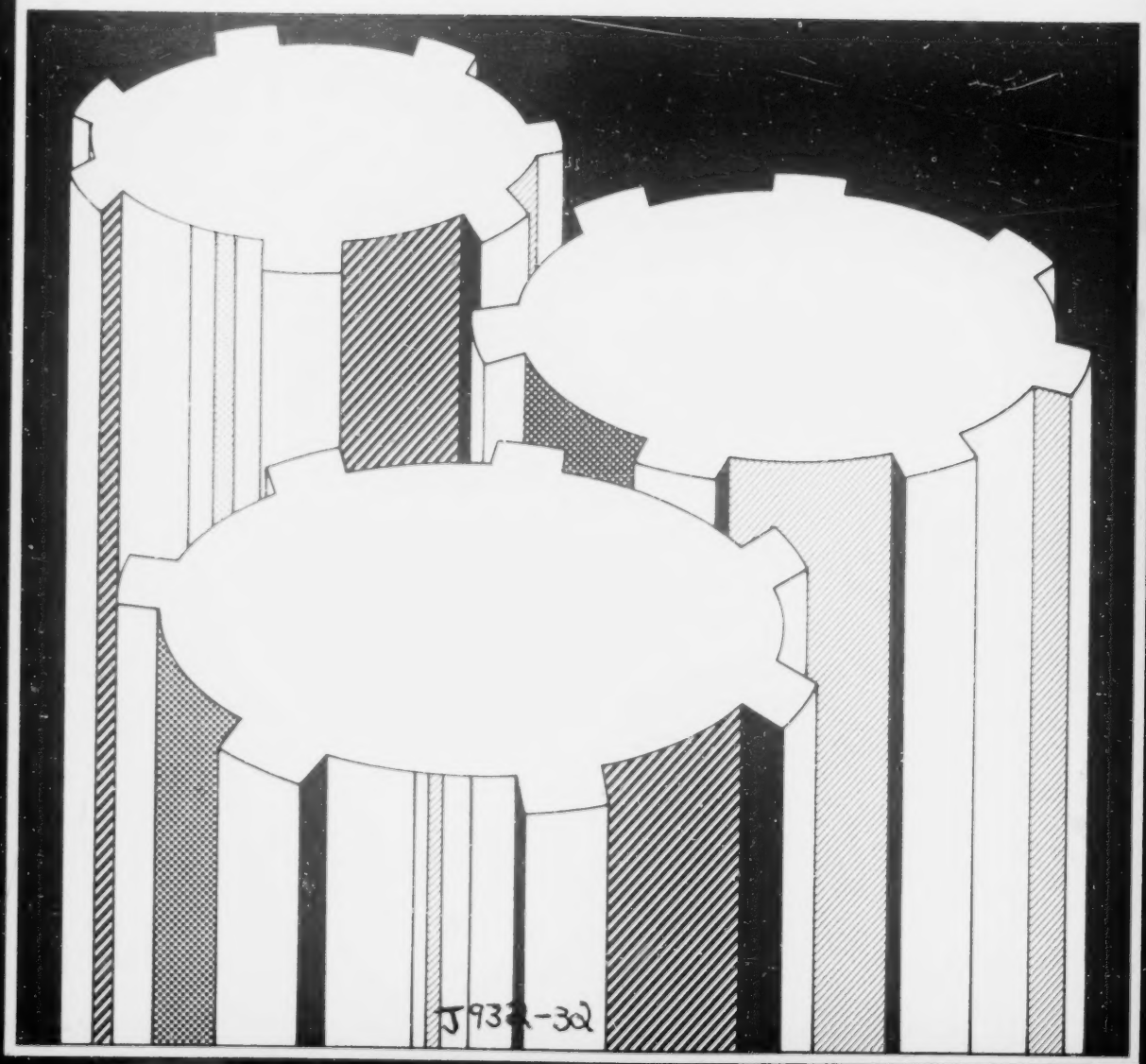
Trends in Public Investment



CBO STUDY

TRENDS IN PUBLIC INVESTMENT

The Congress of the United States
Congressional Budget Office

NOTE

Unless otherwise noted, all values are in 1982 prices and all years are calendar years.

PREFACE

Have the large federal budget deficits of the 1980s financed public consumption at the expense of private investment, as official data indicate? Or has some federal spending bought public investments that, like their private counterparts, contribute to national wealth? This study examining these issues was prepared for the Joint Economic Committee of the United States Congress.

The study was written by Jenifer Wishart of the Natural Resources and Commerce Division under the supervision of Everett M. Ehrlich. Many people contributed to the development of the report. Within CBO, Frank S. Russek, Marvin M. Phaup, Robert W. Hartman, R. William Thomas, Maureen McLaughlin, Daniel Koretz, and David Elkes made helpful suggestions, while Andrew Haughwout, Mark A. Weatherly, and R. Mark Musell contributed important data. John C. Musgrave and David J. Levin of the Department of Commerce provided valuable assistance on national income concepts and measures. Francis Pierce edited the manuscript. Gwen Coleman and Kathryn Quattrone prepared the paper for publication.

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SUMMARY

The great increase in federal deficits in recent years has given rise to fears that federal borrowing may be financed from private savings that would otherwise be available for business investment. In response, some analysts have suggested that much federal spending represents productive investment that adds to the nation's wealth. If so, the deficits have not represented as large a drain on domestic saving as their numerical size would suggest. The decline in net private domestic investment in the 1980s may, in this view, have been partly offset by the investments made by the federal government. Some analysts also argue that federal investment contributes to the long-run strength of the economy by stimulating private investment in certain areas that would otherwise be neglected.

The extent to which federal spending has added to the nation's wealth depends on the answers to two questions:

- Which forms of federal spending are investment?
- How is the value of these federal investments to be assessed?

WHAT IS INVESTMENT?

Investment may be broadly defined as activity that creates assets having value because they produce future output and income. The National Income and Product Accounts (NIPA) of the Department of Commerce treat as fixed investment all expenditures on new business plant and equipment, and purchases of new dwellings by homeowners. Both of these yield future income or output: firms use their plant and equipment in the production of goods or services; and households owning their houses receive a flow of services from the use of their dwellings (imputed by NIPA as a rental income).

The NIPA view is a restrictive one. In current NIPA accounting, government purchases of long-lived fixed facilities are not considered

as investment even when they are made by such industrial entities as the power marketing authorities. This is because the purchases cannot clearly be shown to produce income (as officially measured). The only correction now made to deficits or surpluses in public-sector accounts in the NIPA is for federal lending and land transactions (both representing asset exchanges, not investment), which are netted from total federal expenditures. All other expenditures--whether to construct federal buildings, pay employees, provide funds to states or grants to individuals, or to promote scientific, military, or commercial goals--are treated as consumption. The difference between government revenues and expenditures thus represents public saving or dissaving. National saving is the sum of public and private saving.

But some federal expenditures could be seen as investment without violating the spirit of the NIPA approach--that investment produces future income or benefits. Government saving would then be increased by the value of gross federal investment in any year, and decreased by the annual depreciation of past investments (capital consumption). Such public investment would then become a component of net national fixed investment.

If the NIPA rules for private investment were applied to federal activities, the following might be counted as federal investment: purchases of physical assets used to produce economic services such as irrigation water, electric power, or office space; purchases of equipment operated by federal agencies (such as vehicles and computers); and construction of long-lived structures that are not used directly in economic activity but that have counterparts in private firms, such as airplane hangars used by the military forces.

The NIPA concept of investment might also be extended to include other long-lived assets that produce income or other benefits in the future, although these inclusions would require parallel changes in the treatment of nonfederal activities as well. Such extensions could include:

- Defense Weaponry. Major defense systems are long-lived and produce a stream of future benefits in the form of deterrence even if these benefits are not reflected in national income accounting.

- Research and Development Activity. Scientific findings create future income. Research and development activity (under both federal and private financing) could therefore be deemed a form of investment. Comparable expenditures in the private sector are now accounted as operating expenses, so the NIPA data would have to be adjusted to maintain consistent national income and investment totals.

- Investment Grants to Other Sectors. Federal policies subsidize investment by other sectors. Federal assistance, for example, defrays much of the cost of building highways and other infrastructure. The federal "share" of these investments could be credited to national investment totals, but would be treated as a part of state and local government investment.

- Human Capital. Some economists view workers' stocks of knowledge and skill as capital, comparable with plant and equipment. Expenditures to build these stocks, such as those for education and training, could be viewed as investment. Again, comparable private expenditures would have to be similarly adjusted, and federal aid might be considered as adding to investment totals in the sectors where education expenditures are made.

MEASUREMENT PROBLEMS

After identifying certain federal activities as investment, the question arises how to value them. A dollar's worth of federal investment must be "as good" as a dollar's worth of private investment if it is to be counted equally. Market signals lead private investment values to reflect the economic wealth they create. But comparable federal investments--large dams, for example--are constructed not only for their economic benefits, but to achieve broader, social goals as well. In some cases, these noneconomic goals may detract from the economic contribution of federal investments; in others, the economic effects may be broadly cast and difficult to attribute to the investment. Moreover, some private investments fail and others receive subsidies through the tax system or other mechanisms.

In the NIPA accounts, all private investment is valued at its purchase cost. While such treatment can be defended for private investment that satisfies a market test, it could be less defensible for government investment. On the other hand, it is difficult to value government investment in any way other than to use its purchase cost. That procedure is used in this study.

Another measurement problem concerns depreciation--assigning a value to the portion of the capital stock worn out each year by use, age, or obsolescence. In business, depreciation accounting rules are based on the tax code, prices of secondhand equipment and structures, and on industry practices regarding useful lives and replacement rates. But for much government investment, these rules and practices have not been developed.

In this analysis, two methods were used for depreciating physical assets: deducting equal annual amounts from an asset's value over its estimated service life (as defined for these purposes by the Department of Commerce's Bureau of Economic Analysis), and deducting the entire value of the asset in the year it is assumed to be withdrawn from service. The second measure generally gives a higher estimate of net public investment, since the assets created by recent higher levels of spending in all federal activities are yet to be withdrawn from service, and therefore are not depreciated. Defense assets are depreciated according to the first rule (often called straight-line depreciation) because it reflects the combination of technological obsolescence and physical wear and tear to which such assets are subject better than the inventory approach that the second rule implies.

The depreciation of intangible assets, such as those resulting from investment in research and development (R&D), raises other problems. The capital value of the application of scientific knowledge to a specific product or process (the development part of R&D) is assumed, in the estimates that follow, to depreciate evenly over a 10-year period beginning five years after the expenditures are made. This is done to reflect a gradual reduction in the productivity of earlier development activity as innovations are embodied in new products. This estimate of net investment in R&D is less sensitive to the depreciation rate used than to the choice of R&D activities that may be considered capital-creating.

RESULTS

When measured under the NIPA concept applied to firms and households, federal investment does not contribute a very large part of total national investment. It is heavily concentrated in large construction projects (such as dams and other water resource improvements) and other physical plant. If these are depreciated on a straight-line basis, net federal investment over the last 15 years has averaged about zero, with annual additions or subtractions no greater than $2 billion (in 1982 prices). Using the other measure of depreciation, which writes off assets only when withdrawn from service, net investment by the federal government has averaged about $4 billion annually (again in 1982 prices) over this time period.

The largest sources of net investment have been in dams and other resource conservation structures, and in industrial equipment (as used, for example, in federal ship construction) owned and operated by the federal government. The largest sources of net disinvestment have been in military structures, such as hangars and barracks. In many cases, however, the depreciation charges calculated for military structures are overstated since the structures themselves are often obsolete or exceed peacetime requirements.

Were federal investment measured using broader concepts it would add as much as $60 billion to net national investment in 1986 (in 1982 prices):

- Net spending on defense assets would add $17 billion;
- Net federal research and development aimed at commercial innovation would add $10 billion to $20 billion; and
- Federal subsidies for state and local physical investment (such as infrastructure) would add a net $11 billion to $22 billion.

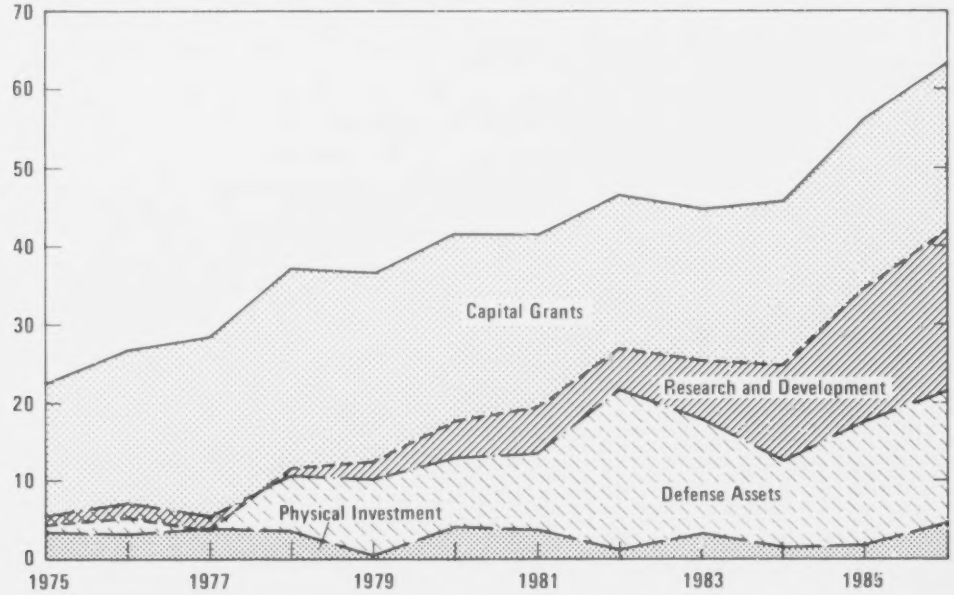
Trends in investment under the NIPA concept and these three extended concepts of capital are shown in the Summary Figure. Federal spending on education and training assistance totaled around

$20 billion in 1986, but this overstates the gross addition to human capital that many analysts would attribute to such federal assistance because these subsidies sometimes accrue to individuals who would have pursued education without them. Moreover, no reliable estimates of depreciation can be formulated for education investments.

Net investment in defense assets--weapons, ships, aircraft, and the structures that support them--has increased dramatically since the 1970s. In the first half of that decade, net investment--compared with a gross investment of around $20 billion a year--was negative. Steady increases beginning in 1975 brought gross investment to $33 billion by 1979, and raised net investment to $10 billion. Increases in both gross and net totals continued until 1982 when gross investment reached $47 billion, and net investment peaked at $21 billion. In

Summary Figure.

Net Investment Attributable to Federal Budgets Under Different Concepts (NIPA basis, in billions of dollars, at 1982 prices)



SOURCE: Congressional Budget Office, based on data from Bureau of Economic Analysis, National Science Foundation, and Office of Management and Budget.

NOTE: The figure shows the larger measure of net investment under each concept.

1986, net investment of $17 billion came from gross investment of $56 billion. Differences between gross and net investment in this case reflect straight-line depreciation estimates. Calculating depreciation charges for the stock of weaponry is an uncertain exercise, although it is undeniable that weapons are exposed to technical obsolescence and to wear and tear.

Net investment in research and development has also increased dramatically in the 1980s, rising from negative levels in the mid-1970s to $20.3 billion in 1986. Most of the increase has occurred in military development applications, which have risen from negative amounts as late as 1982 to $12.4 billion in 1986. But 90 percent of military R&D spending is for development (including the procurement of prototypes), with only the remaining 10 percent for basic or applied research with broader applications. Excluding the development part of military R&D, and also other noncommercial development in the space, health, and environment R&D programs, puts net federal R&D investment at around $11 billion annually throughout much of the last decade.

A further expansion of the definition of federal investment would include federal financing of investment in other sectors--most notably, income transfers made to support the infrastructure investments of state and local governments. Since 1982 the federal government has financed approximately $11 billion per year in net state and local government infrastructure investment, down from a peak of about $18 billion in 1978 (using straight-line depreciation). If depreciation is deferred until assets are withdrawn from service, however, net investment has totaled about $20 billion annually since 1982, compared with levels of around $25 billion in the late 1970s. To some extent, lower levels of net investment in the 1980s under both estimates reflect lower federal spending for all infrastructure except highways and airports. In addition, one-time emergency public works investments made in the mid-1970s are now depreciating, reducing the net investment total.

Much federal spending is dedicated to the general functions of education and training. These activities are often thought of as creating "human capital," a form of wealth in its own right. But many people pursue education or training for other than investment or job-

related purposes, so that the returns to these activities are often nonmonetary. There is no satisfactory way of separating investment and personal spending in this category. Moreover, selecting a rate of depreciation is virtually impossible.

Federal spending on education and training services, according to the NIPA, rose from around $23 billion in 1975 to a peak of around $25 billion in 1980 before falling to the current level of about $17 billion (all in 1982 dollars). To this may be added the value of loan subsidies offered by the federal government for education and training; these were worth approximately $2.9 billion in 1986. The value of these loans has risen in the past 10 years, but not by enough to offset the diminution in spending. These are raw data, however. They do not separate what are clearly investment activities from those that are avocational. Nor do they reflect the inherent depreciation of past education and training.

Despite the rising level of net federal investmentlike spending, however, adjusting official data in these ways would not offset the fall-off in net private fixed investment evident during the 1980s. Net federal physical investment (less than $4 billion a year) has remained at about 0.1 percent of net national product (NNP), while the rate of private domestically owned fixed investment has fallen by around half, from just over 7 percent of NNP in the early 1980s to under 4 percent in the five-year period 1982-1986. Under the broader federal investment concepts, federal net investment does not exceed 0.6 percent to 0.7 percent of NNP for each concept, adding at most only about 2 percent to the official estimate of the ratio of investment to NNP, split about equally between the federal (1.2 percent of NNP) and state and local governments.

CHAPTER I

INTRODUCTION

A major source of concern with record levels of the federal deficit arises from their inhibiting effect on private investment. In fact, the 1980s have witnessed an increase in deficits simultaneous with declines in both net private domestic investment and saving. As deficits rose from slightly under 2 percent of net national product (NNP) in the 1970s to about 5.4 percent of NNP in the 1982-1986 period, net private domestically owned investment fell from an average of 8.5 percent of NNP in the 1970s (and a cyclical high of 8.4 percent in 1979) to an average of 3.7 percent in the 1980s.1/ A parallel decline occurred in domestic saving. (Box 1 defines saving, investment, and capital formation.)

Deficits are sometimes said to "crowd out" private investment by competing for funds in capital markets. To the extent that this occurs, it means that the economy will grow at a slower rate and that future living standards will be lower than otherwise. In recent years, the crowding-out effect was ameliorated by inflows of capital from abroad. As foreign indebtedness increases, however, a rising percentage of future output must be sent abroad to repay foreign lenders.

This view of deficits is predicated on the assumption that federal spending is consumption rather than investment. Official data do not count any of the expenditures of federal, state, or local governments as investment. Thus, in the National Income and Product Accounts (NIPA), almost all federal spending is considered public consumption, and deficits are therefore a form of public dissaving.2/ In NIPA data,

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1. Net national product is gross national product minus allowances for depreciation. Thus, it measures the net amount available to finance consumption and investment.

2. NIPA estimates of federal spending deduct only land purchases and lending transactions from the spending total.

BOX I.
SAVING AND INVESTMENT

"Saving" is that portion of the flow of national income not consumed in any one year. Saving is an addition to the nation's wealth: it diverts resources from current consumption and makes them available for future consumption.

"Investment" is the purchase of durable goods that are used to make other goods and services in the future. Just as saving adds to the nation's wealth, investment adds to its capital stock--after taking into account the depreciation that naturally occurs to the capital stock as it wears out or becomes obsolescent.

In a world without foreign trade and with balanced government budgets, the nation's private saving would of necessity be equal to its investment. In an accounting sense, private saving is that portion of income that is not consumed, while investment is that portion of output that is not consumed. Since the nation's income ultimately is equal to the value of its output (as income can only be earned by producing some form of output) saving and investment must also be equal. The National Income and Product Accounts (NIPA) express this identity by stating that:

Saving (S) = Investment (I)

A government deficit can be incorporated into this balance. The government's fiscal surplus is public saving, and is available for the same purposes as is its private counterpart. Alternatively, when government spending (G, in the NIPA) exceeds tax revenues (T), the deficit (G-T) must be financed through borrowing. This borrowing must originate in private saving. Thus, fiscal deficits are a form of public dissaving. The NIPA add the government deficit to the saving/investment identity as follows:

S = I + the Deficit (G-T)

Foreign trade can be incorporated as well. When the nation has a trade deficit--in NIPA nomenclature, when imports (M) exceed exports (X)--the economy must borrow money from abroad to finance its excess purchases of foreign goods. This borrowing from abroad--net capital inflow--is a debt incurred by the nation that detracts from saving. Alternatively, when the nation runs a trade surplus--when exports exceed imports--it accumulates the foreign currency that was used to purchase its goods. It can use this currency to purchase foreign assets. But the funds for these purchases of foreign assets must be taken from domestic saving. Thus, private domestic saving must cover investment, the government's deficit, and the purchase of foreign assets financed by a trade surplus. Domestically owned private investment is then the sum of investment (I) and the trade surplus (X-M). When the economy engages in international trade, lending, and borrowing, the NIPA identity is extended as follows:

S = I + (G-T) + the Trade Surplus (X-M)

The effects of government deficits can be explained in the context of this identity. If the deficit (G-T) increases, then three possibilities exist for restoring the inevitable mathematical balance described by this equation:

- Private domestic saving can increase;
- Investment can decrease; or
- The trade surplus can decrease (or, alternatively, the trade deficit can increase).

There is little reason to believe that private saving will increase simply because deficits become larger. While some economists have attempted to develop a theoretical reason why it would, most evidence runs to the contrary--particularly the dramatic decline in observed saving during the 1980s, a period of rapidly rising federal deficits. Instead, the other two responses have been observed: investment has declined, and the trade deficit has swelled.

This report focuses on investment trends in the federal budget. Since all federal outlays are now classified as consumption in the NIPA, any reclassification of these activities as additions to the nation's capital would serve to increase investment in the economy as measured by the NIPA. In the equation above, it would lower government spending, or G, since all the spending included in G is presumed to be consumption, and increase investment, or I, commensurately. One would then be conceptually consistent in classifying the value of that federal investment as saving, since it would no longer be consumption. While private saving need not increase, recognizing some government spending as a form of investment would imply that some portion of tax revenues is a form of collective saving by society. For the sake of simplicity, however, this report focuses on the investment side of the equation and observes how trends in federal investment could affect the accounting data for national investment.

as shown in Table 1, most of the decline in saving in this decade can be attributed to the rising federal deficit. Figure 1 illustrates the long-term trends in national saving and investment.

Much government spending, however, is for new fixed facilities and equipment that provide productive services over a long period. In many instances, such expenditures would be considered investment if undertaken by a private firm. If federal spending of this kind were considered to be as productive as private investment, the result might be to alter the picture given by official data on national saving and investment, leading to a more positive prospect for future economic growth.

This paper analyzes federal spending to determine how much of it can be counted as investment, and how large such investment is relative to net private investment and to the federal deficit. Three questions underlie the task:

TABLE 1. THE SHARE OF NATIONAL OUTPUT DEVOTED TO INVESTMENT AND SAVING
(NIPA basis, in percent of net national product)

Item	1960-1969	1970-1979	1980-1981	1982-1986
Nonfederal Saving a/	9.3	10.4	9.5	9.1
Federal Saving b/	-0.3	-1.9	-2.4	-5.4
Total Saving c/	9.0	8.5	7.1	3.7

SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

a. Saving of private, business, and state and local sectors.

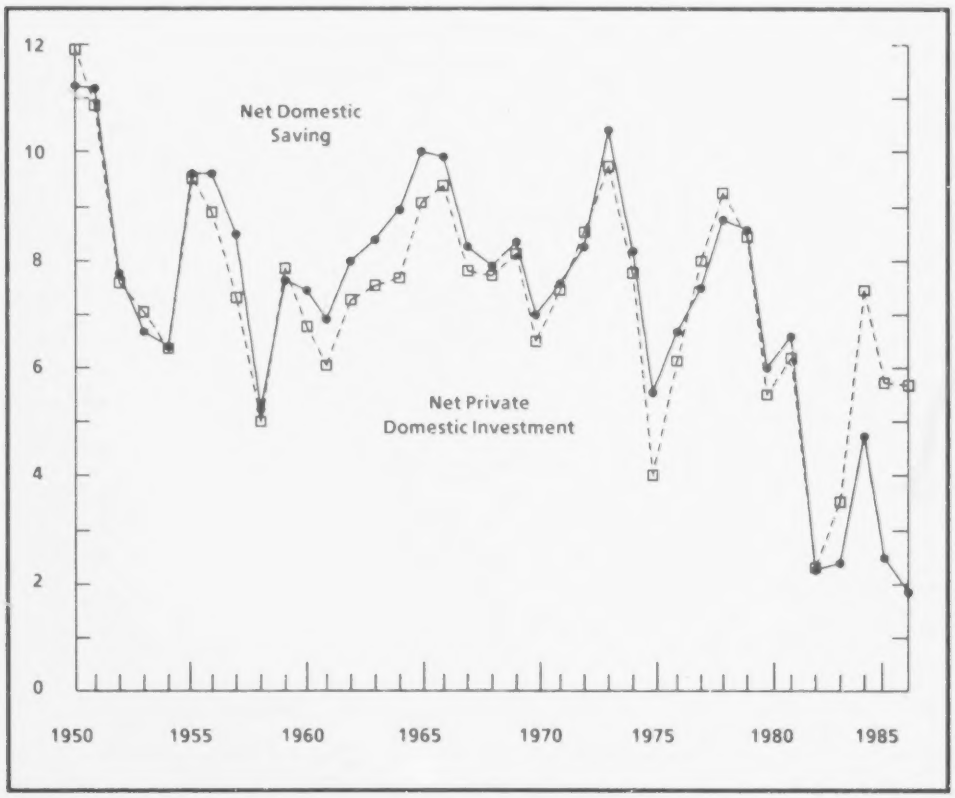
b. NIPA basis, with a negative number denoting a deficit.

c. This sum of rows 1 and 2 is also equal to domestic net investment less export surplus. Since the latter equals net foreign borrowing, line 3 is also domestically owned net investment.

- What is investment?
- What is its federal component?
- How should its value be measured?

The first question seems to offer no problem. NIPA data on net private investment include new physical assets that will be used to produce future output. The second question is more difficult: answering it

FIGURE 1. NET NATIONAL SAVING AND INVESTMENT AS PERCENT OF NET NATIONAL PRODUCT



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

requires appraising which federal purchases are similar to such private investment. Federal expenditures for the construction of federally owned dams or other such structures belong to this group. But other federal expenditures may be considered investment by a broader definition. Just as investment in physical assets adds to the nation's tangible capital, spending on research, education, or other activities is sometimes regarded as contributing to its intangible intellectual and human capital. Further, governments have broader aims than private investors; they construct facilities to provide benefits other than income, such as the benefits of national security resulting from expenditures on defense. Finally, federal subsidies encourage other governments and private actors to make investments of their own. All of these activities might be considered federal investment under varying definitions or concepts. Thus, answering "what is investment?" and correspondingly "what is its federal component?" requires examining a wider range of investment concepts.

The third question calls for consistent and reliable measures of value. The values assigned to federal investment should reflect the services it provides; an additional dollar's worth of federal investment should provide the same value of services as a comparable marginal dollar of private investment if it is to be measured correctly. But there are no markets to establish prices for many government assets, and available data reflect only construction or acquisition costs. A cost-based measure of value is valid only if it reflects rates of return on federal investments that are comparable with those earned by private investments, so that, dollar for dollar, public and private investments may be considered equal contributions to wealth. Additional measurement issues concern the same questions of depreciation, obsolescence, and useful life that are relevant when valuing private investments.

This study approaches these issues using the framework of the National Income and Product Accounts as a starting point. This framework counts as investment those private purchases of durable structures and equipment that contribute to the production of future national output. By and large, this conforms with the conventional view of investment as purchases of business plant and equipment. A different definition is used by the Office of Management and Budget (OMB) in its Special Analysis D (which compiles federal outlays that

"yield long-term benefits"). Special Analysis D includes all federal outlays that produce lasting benefits of any kind. Thus, OMB includes outlays that range from the construction of physical assets to student loans to the conduct of the census. Moreover, until the 1985 budget, the OMB series set forth only gross investment and not the net investment measures that show the extent to which real additions to wealth have occurred.

NIPA data do not now include federal investment, and estimates of it therefore require extending the NIPA framework to government spending. The NIPA framework is thus first used to identify federal investment that can be compared directly with official data on private investment, and then to examine possible extensions of the concept of investment to cover investment in defense assets, scientific or intangible capital, federal investment subsidies, and human capital.

CHAPTER II

DEFINING PUBLIC INVESTMENT

Identifying trends in federal investment requires distinguishing those federal activities that qualify as investment. Private investment is identified and measured in the National Income and Product Accounts of the United States. This chapter describes the NIPA view of investment and applies it to federal activities. It then examines possible extensions of the NIPA view that would allow broader definitions of federal investment.

THE NIPA CONCEPT OF INVESTMENT

The NIPA do not provide a formal, specific definition of those economic activities that are considered investment. Rather, a definition of investment must be inferred from the many decisions the NIPA make as to those activities that are and are not included in this category. The NIPA generally regard as investment the purchases of durable goods (such as equipment or structures) that are used by businesses to create future output and, in turn, income. This implied definition has two important implications. First, the goods characterized as investment are tangible, as implied by the emphasis on durables. Second, investment leads to future output and, therefore, is an activity found in the business sector, since it is only the business sector that, in the view of the NIPA, creates economic output and income. (The income earned by providing government services, for example, is attributed to the taxes paid or the dissaving incurred to pay for government spending.) While no formal definition of investment is provided by the NIPA, these two principles consistently appear in the calculation of investment.

The sole exception to this rule concerns purchases of owner-occupied housing, which are considered investment. This exception is made because home ownership provides households with an imputed

stream of income equal to the rent that they need not pay. Even though the income is not taken as cash, it nonetheless exists--households, in this view, are like businesses that rent their houses to themselves. While it can be argued that other purchases of durable goods--automobiles, for example--also provide income streams, home ownership is the sole exception allowed in the NIPA.

According to this view, governments do not invest. In compiling NIPA estimates of national economic aggregates, almost all government expenditures are considered current expenses, or a form of public consumption. Thus, under the NIPA, the public sector's budget deficit is a form of dissaving and affects national investment to the extent that dissaving reduces the resources available for investment.1/

Government purchases of fixed facilities similar to business plant and equipment are not counted as investment in the NIPA, in part because they are not managed the way a private enterprise might manage them. The NIPA effectively treat all government activities--even those that resemble private investment--as if they generate no new income in the future. In practice, it is often difficult to separate the extent to which publicly owned facilities will generate future income (as do firms) from the extent to which those facilities represent future subsidies to their users provided by taxpayers. Yet despite this distributional issue, the outputs of these activities often strongly resemble the outputs of private investment.

Applying the NIPA Standard to the Public Sector

The NIPA accounting view clearly fails to reflect the investmentlike effects of government activities. If the standard of durable goods that produce future output and income were applied to governments, some

1. Under the NIPA rules, government outlays for net land purchases and new loan disbursements are thus included in government saving measures offset, in national totals, by private dissaving through land sales and loan liabilities. Other coverage differences between the NIPA and the unified budget are that the NIPA measure includes all on- and off-budget agencies, but excludes social insurance receipts and payments to residents of U.S. territories and Puerto Rico. The NIPA measure also makes other adjustments for accruing revenues and expenses so that measures of government budgets are consistent with income measures for other sectors.

of their activities could well be considered investment. States and localities, for example, own and operate utility companies that provide water, electricity, gas, and transit services as do private firms. The federal government has a worldwide network of defense installations that includes such facilities as hangars and docks. It also operates a national system for air traffic control and a national space agency, both of which provide commercial services. All levels of government own substantial property--vehicles, computers, and offices--used in conducting their affairs. In fact, at the agency level, government accounting practices separate investment from consumption transactions, and many agencies present balance sheets showing proposed changes in assets along with budget spending requests. 2/

If the NIPA distinction between capital and current purchases by households and businesses were also used to differentiate investment from other spending in federal budgets, then purchases of structures and equipment used by federal enterprises and other entities to produce future income would qualify as investment. According to this view, these expenditures have provided the nation with a capital stock that has helped to produce either goods bought and sold in commercial activities or public services. Included would be the construction of fixed facilities by federal power authorities and other federal enterprises, by the Postal Service, and by the agencies that manage water and energy resources (since, even when not operated commercially, these provide commercial inputs to agriculture and townships). Also included would be the construction of public facilities, like roads, that generate future economic benefits.

New tangible assets--like federal buildings or computers--would also be included as government investment. While not used directly in businesslike activity, these items provide a measurable output that affects the cost of providing federal services. For example, the purchase of a federal computer obviates the need to rent the services of such a machine from private firms, just as owner-occupied housing obviates paying rents. Yet, in the absence of government purchases, private firms could have purchased a computer and subsequently rented it for a profit to the government; this would have allowed its

2. See, for example, National Aeronautics and Space Administration, *Budget Estimates Fiscal Year 1988*, vol. 2, Construction of Facilities.

inclusion as investment in the NIPA. Thus, these federal purchases could be defined as investments.

The Bureau of Economic Analysis compiles data on national wealth that include measures of fixed assets and equipment in the public capital stock.3/ This data series is used in this paper. It is supplementary to the main national income accounts and is derived from NIPA data on government purchases of structures and durable equipment, but these purchases are not counted as investment in NIPA measures of national investment.

Recognizing government investment in national accounting would change measures of national capital formation. Government investment--and national saving, since government purchases would no longer be treated as consumption--would be increased (and deficits reduced) by the amount of annual spending defined as investment. Treating federal investment in a fashion parallel to business investment would also require calculating the yearly deduction for capital consumption, or depreciation, on the public capital stock and adding it to current expenditures, paralleling firms' accounting for the costs of capital services from their plant and equipment in producing their outputs. Federal government dissaving would then be equal to the deficit minus the net change in the value of the federal capital stock.

EXTENDED CONCEPTS OF CAPITAL

Many researchers have found the NIPA concept of investment restrictive and have compiled alternative series for national investment. Most of these analysts adhere to the NIPA principle that the defining characteristics of capital are that it is long-lived and creates benefits in the future, but they also extend the range of activities that are considered investment.

Some argue that governments often do not have businesslike objectives and that their investment should be measured relative to

3. See Department of Commerce, Bureau of Economic Analysis, *Fixed Reproducible Tangible Wealth in the United States, 1925-1985* (July 1987).

what they do, rather than to what produces "income." For example, the federal government provides goods or services that produce "welfare" or "well-being," though not measurable income. Among these are the preservation of pristine natural areas; continuity of the culture through the arts; law and justice; and defense activities. Of these, the most important source of investmentlike activity is in the untraded (non-NIPA) stock of defense assets.

Others note that the concept of long-lived assets that create future income could be applied to various types of intangible or intellectual capital. In fact, these types of assets are useful in explaining changes in productivity, suggesting that "intangible" capital--the store of knowledge from findings of research activity--plays a role like that of physical capital in the production process. Certainly, research and development (R&D) produces innovations in products or production processes that generate profits and higher future income.

In other cases, federal activities subsidize investments that occur in other sectors. For example, federal funds pay for a portion of the nation's highway system, even though the resulting roads are owned and maintained by the states. Nonetheless, these investment subsidies might be treated as the federal share of an investment originating in its sphere.

Many researchers studying economic growth have used the concept of "human capital"--the store of skill and other labor services in people--since it was developed in detail in the early 1960s. 4/ This concept extends the idea of capital to include the skills and abilities brought to production by labor. Just as equity holders own the plant and equipment that produce goods and services (and, in turn, profits), workers have reserves of knowledge, skill, and experience with which they earn their incomes. Capitalizing such reserves gives a measure of human capital.

There is no agreement among economists that any or all of these expansions of the NIPA definition of investment are warranted, although a case can be made for each. Nonetheless, applying these

4. See Gary S. Becker, *Human Capital* (New York: National Bureau of Economic Research, 1964).

concepts would lead to four possible extensions of measures of federal investment, all of which reflect the principles underlying the NIPA definition of investment while extending the actual measurements beyond those consistent with NIPA data for private investment. In most cases, to maintain consistency, equivalent extensions would have to be made for measuring investment in private sectors--just as extending the NIPA concept for federal accounts would require equal treatment for state and local budgets.

The four extensions of the NIPA definition of investment considered in this report are explained below.

Investment Providing for National Defense. The federal government buys long-lived weapons systems that, although they do not produce measurable future income, provide deterrence services over several years. An expanded federal investment series could, therefore, treat such purchases as investment, with their return being the unmeasurable benefits of deterrence.

Investment in Intangible Capital. Nearly half of the national research and development activity is now performed in or under contract to federal agencies. This contributes to scientific or intangible capital that assists in generating commercial innovations.

Investment through Federal Capital Subsidies. Federal spending accounts for half of all national spending on public facilities and infrastructure, most of it through grants to state and local governments. Subsidized federal loan programs also help to finance private as well as public capital projects. Extending capital concepts to include investment subsidies would need conventions to avoid double counting: private investment data already include many subsidized components, and federally financed state or local investments would have to be attributed to a single sector or split.

Investment in Human Capital. Like investment through grants, human capital investment is made not by federal agencies but by subsidy recipients. Thus, if human capital were included in the NIPA, most adjustments would be made to household spending. Nevertheless, federal financing for human capital could be considered a federal contribution to investment.

Table 2 shows federal expenditures that could be reclassified as investment under the view of business and household investment currently used in national accounts estimates, as well as those under each of the four extended views. (The latter would also require some changes in national estimates of investment in other sectors.)

Regardless of whether these extensions of the NIPA definition are considered acceptable, the fact that new long-lived federal physical assets that create future output and income are not considered "investment" suggests that NIPA practices now understate national capital formation. This leads to the question of whether including public investment would substantially change the picture of national investment. Part of that answer rests on how reliably federal investment can be measured and its subsequent depreciation estimated.

TABLE 2. FEDERAL EXPENDITURES QUALIFYING AS INVESTMENT UNDER DIFFERENT CONCEPTS OF CAPITAL

	National Accounting Concepts		Extended Concepts
	Current National Income and Product Accounts (NIPA)	Business and Household Capital Concepts in NIPA Extended to the Federal Sector	Weapons and Weapons Carriers Used in National Defense Activity
Included as Investment	No federal expenditures are counted as investment in current national income and product accounts.	Federal purchases of fixed facilities and equipment used in producing national income would be included.	Federal purchases of major weapons systems, weapons carriers, and tactical vehicles could be included.
Examples		Investment would include federal expenditures for purchase or construction such as: -office and other buildings -water resource development projects -military base facilities -federal housing -major equipment -assets of power marketing authorities -physical assets of research and development agencies	Investment would include purchases such as: -aircraft -missiles -ships -armored vehicles -support equipment
Required Parallel Changes		State and local government purchases of fixed assets would also be reclassed as investment.	Expenditures for defense buildings and bases are included under NIPA investment concepts.

TABLE 2. (Continued)

Extended Concepts (Continued)

Intangible Capital	Federal Subsidies for Capital Investment	Human Capital
Federal expenditures for research and development activity could be included.	Grants from the federal to state and local governments for constructing facilities or for purchasing major equipment could be included, along with credit subsidies for capital purposes.	Federal expenditures for human development could be included.
Investment would include federal expenditures for operating agencies and activities such as:	Investment would include federal outlays for capital grants to construct facilities such as:	Investment would include federal outlays and credit subsidies for activities such as:
-defense R&D programs -national laboratories (DOE) -National Institutes of Health -National Science Foundation -NASA R&D -agricultural extension and research -transportation research	-federal-aid highways -community and urban development projects -mass transit -wastewater treatment plants -airports -schools and hospitals and credit subsidies for: -rural electrification -rural water supply -small business development -housing	-education grants to states -student assistance -job training
Private research and development spending would also be reclassed as investment under this concept. Purchases of plant and major equipment used in research fall under the NIPA investment series.	To avoid double counting, state and local investment totals under the NIPA concept could be reduced by the amount of capital grants, or grant-financed investment, attributed directly to other governments.	Similar spending by households and businesses would be reclassed as investment.

SOURCE: Congressional Budget Office.

CHAPTER III

VALUING FEDERAL INVESTMENTS

What are federal investments worth? Beyond the problems inherent in identifying federal programs that create capital lies the issue of assigning a value to that capital. Economists generally recognize several different approaches to valuing private capital traded in markets. Valuation becomes even more difficult in the special circumstances of federal investment.

This chapter discusses issues that arise in valuing federal investment, including:

- The implication of using outlays for fixed facilities as a measure of the value of investment;
- How investment subsidies (from both taxes and credit programs) affect the value of investments; and
- What rules for depreciation are appropriate for the public capital stock.

The value of investments is a measurement issue insofar as the NIPA use the cost of investments as a measure of their value; at issue is whether this practice is suitable for public-sector investments. An investment is worth the future stream of benefits it will provide. The value of these benefits depends on events yet to occur. An active capital market will establish values for all investments, based on what investors are willing to pay to secure ownership of the future benefit streams. Since investment adds to the stock of capital, the governing prices in these markets reflect how the addition of extra capital is valued. Investment will expand until the price buyers will pay for the benefits is equal to the costs of producing (or replacing) the assets that provide them (adding the noncash costs associated with management, decision-making, and risk-taking). Over the long term, active markets with flexible prices will tend to equilibrate the three

cash value measures--what buyers are willing to pay, what assets cost to produce, and what they would cost to replace. More speculative investment projects, with uncertain future streams of benefit payments, will have high noncash costs and will ordinarily sell for less than cash cost so as to cover their noncash costs and induce sales. As uncertainty declines, the market worth of the marginal investment and the cash cost of producing it tend to approach each other. Thus markets tend to brake private investment once the last project has been undertaken that will repay its construction cost in future benefits. Projects that cannot repay their costs will not generally be undertaken. Even though some investments are subsidized and others prove mistaken, the wealth created through private investment will tend to equal at least the construction or contract cost of the facilities.

The logic of public investment is different from that of private investment and, therefore, similar measures of the wealth created by federal investment are difficult to establish. Data on outlays for federal investments may over- or understate the value of these investments. Since government projects are motivated by both economic rates of return and social goals, government investment tends to expand beyond what strictly wealth-creating criteria would advise private investors to do, and thus federal construction may provide lower rates of return than private investment in terms of the future income it will generate. Moreover, federal spending on investmentlike activity often takes the form of subsidies for investment by others. Yet the investment resulting from federal subsidies should be credited to federal investment only if these subsidies actually stimulate new activities dollar-for-dollar.

Some federal investments--such as those that predicate regional development or scientific discovery--may have very large rates of return, but these returns may be so broadly dispersed throughout the economy that they are difficult to attribute and measure. Moreover, the value of some private investments may depend critically on the existence of federal investments, such as roads or ports. Thus, using expenditures (in the case of the federal government, outlays) to measure the value of both public and private investments reflects the assumption that the problems of the relative worth of these investments are largely self-canceling and that public investments are, in the aggregate, substitutable for private ones on a dollar-for-dollar basis.

MEASURING FEDERAL INVESTMENT OUTLAYS

The investment value of federal construction and equipment purchases is difficult to measure. The dominance of the federal government in many relevant markets means that contract prices cannot be taken as a reliable measure of the value of federal transactions. Furthermore, low prices for the services produced by government facilities may result in inflating the demand for them, so that demand often cannot be used to estimate the benefits of the facilities as a check on investment values based on construction cost. But construction or contract price data are commonly the only measure of investment that is available.

Government intervention in economic activity is often to provide goods or services that are socially worthwhile but that entrepreneurs would not find profitable to produce or sell. Typically, such intervention may provide public goods that are available to all without restriction (such as national defense); or the intervention may be to correct or prevent adverse effects of other activities in the economy (as in pollution abatement programs); or it may pursue social goals (such as regional development). To be nationally worthwhile, fixed facilities constructed for these purposes need not be backed by an identifiable future income stream that recovers the cost of constructing them. In NIPA terms, the income they generate would then be less than their construction costs, even if the investments create social benefits or unattributable economic benefits.

This is the dilemma of the NIPA accountants and the reason they exclude government structures and equipment purchases from national investment totals. This study values federal investment as the construction cost for facilities (since this is the best information available), just as private investment is measured. But a true measure of the wealth created through federal investment would most likely be less than construction cost.

A further complication is that cost information about government investments is commonly distorted by monopoly price effects on both sides of the markets in which governments do business. These can drive up prices even where competitive bidding is the norm. Under many federal programs, for example, special contracting provisions

are necessary to allow small firms to bid. In other cases--such as salaries in some occupations--governments tend to pay less than market price, so that investments that involve large service inputs from government agencies (for example, planning and designing road networks, or teaching) may be undercosted. Government powers of eminent domain drive prices down, even for so-called free market purchases. This is particularly important in land-intensive natural resource investments. One writer estimates the social costs (measured as the costs of agricultural production and other benefits forgone) of land that would be flooded by the Narrows irrigation development on the South Platte River in Colorado at three times the amount paid in "open-market" purchases.1/

Finally, attempting to value federal investment by trying to measure what the streams of public or government services flowing from the investments are worth is vastly complicated by the pricing of government services. When services are priced too low, for example, users will choose more of them than they would at a price reflecting real costs. This contributes to an appearance of high and sometimes excess demand for public facilities. Yet some federal programs expressly provide subsidies for social purposes through less-than-cost user fees for infrastructure and other facilities. Others provide broadly based benefits that cannot adequately be reflected in user fee revenues. Where fees are low, federal outlays for capital projects meeting these demands are unlikely to reflect their contribution to national net worth.

MEASURING FEDERAL INVESTMENT SUBSIDIES

Data on federal investment subsidies also suffer from measurement problems. Three common types of investment subsidy are enhanced credit (low-interest loans for housing, for instance), tax concessions (such as those of the early 1980s that permitted accelerated depreciation and provided investment tax credits), and grants (such as those made to states and localities under the federal highway program). The federal government permits state and local governments to offer

1. Robert A. Young, "Economic Analysis and Federal Irrigation Policy: A Reappraisal," *Western Journal of Agricultural Economics* (December 1978).

tax-exempt bonds, enabling them to borrow at lower cost. Federal credit subsidies are akin to grants, with perhaps only the extent of the federal share of the final investment cost differing. Credit programs enable those who benefit from them to borrow at below-market costs: the amount lent equals the amount to be paid back plus the subsidy provided by federal underwriting. Thus before looking at the investment-inducing effects of subsidies, a "housekeeping" adjustment needs to be made to accounting data on federal lending.

Accounting for Credit

In ordinary commercial accounting, banks and other financial institutions enter the loans they make as assets, the interest they earn as income, and the capital portion of repayments as reductions in outstanding loan balances. These financial transactions are exactly offset (assuming no inflation) in borrowers' accounts so that the overall economic contribution of financial institutions is in the intermediation between savers and investors: no wealth is created in the offering and acceptance of a loan, but the transaction costs of loan-making are reduced and more investment activity results.

A simple accounting of federal loan assets would treat government loans in the same way--no wealth would be created, and federal loan transactions could be ignored in measuring national capital formation. In its credit programs, however, the government rarely functions as a simple financial intermediary: some programs are ways of conferring subsidies for certain groups or for certain purposes. Others--particularly loan guarantees--serve to reduce information or transaction costs, or to transfer risk, and thus enable borrowers to obtain credit where lenders might not otherwise provide it. In other words, the federal credit intervention conveys a value that substitutes for part of the obligations of borrowers to lenders. When it finances an investment by the borrower, therefore, the federal subsidy is analogous to a grant of the same amount for partly financing the investment cost. 2/

2. Quite apart from the share of investments that loan subsidies may finance, however, the accounting for federal credit subsidies as immediate income

(Continued)

Importance of Investment Subsidies

Analysts generally conclude that the investment effects of all three types of subsidy--tax incentives, credit subsidies, and grants--are difficult to measure, but small. Because of their effects on the composition of investment, however, the subsidies may have important effects on the national returns to investing. The investment effect of a subsidy would be the net addition to national worth that follows from extending it. The investment effects of tax incentives, say, would ideally be measured as the net investment induced by the concessions above what would otherwise be economically viable, after also deducting any otherwise viable investment deferred by other provisions of the tax code. Similar "with subsidy" and "without subsidy" comparisons would reveal the investment effects of credit subsidies and grants. The federal contribution to capital formation would then be measured by the difference between these two, and recorded at the time of the investment.

Tax Incentives. Analysts generally believe that tax incentives tend to increase net investment, and that tax provisions may have some influence on the composition of capital. But measuring or predicting the effect on investment of any change in tax rules has so far proved inconclusive.3/ Furthermore, to the extent that incentive effects are real, the higher returns they provide may be reflected in the prices of the investments they favor and thus already included in data on business capital transactions.

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2. Continued

transfers to borrowers significantly alters the measure of net federal saving that is relevant to assessing overall federal contributions to capital formation. This adjustment is now partly made in the NIPA estimates of federal expenditures: loan principal transactions for direct lending are excluded from federal accounts, but the annual interest payments that pass through the budget are included. A better accounting of the resources transfer would capture the value of the federal contribution by estimating the present value of the interest or repayment subsidy conveyed or other values not provided in cash (say, through guarantees) and hence not reflected in either the unified budget or national income treatment of credit programs. These types of adjustment are discussed in detail in Congressional Budget Office, *An Analysis of the President's Budgetary Proposals for Fiscal Year 1988* (February 1987).

3. See, for example, Barry P. Bosworth, "Taxes and the Investment Recovery," *Brookings Papers on Economic Activity* (1:1985).

Credit Programs. For credit programs, likewise, little is known about the size of investment effects. Federal credit tends to alter returns to selected or targeted lending, and may have more effect on the composition rather than the volume of investment. Direct loan subsidies (and tax exemptions for municipal bonds) lower the returns that the investment financed by the loan must pay, if borrowing is to be feasible. They also, however, make lending for such projects as attractive to savers as loans to higher-paying investments. The subsidies thus tend to expand lower-paying investments, and may correspondingly lower national worth compared with the value it would have achieved without competition between subsidized and unsubsidized investment. On the other hand, if measured returns understate the social value of investments, federal subsidies would increase national worth, broadly considered.

Other federal credit programs reduce lenders' exposure and thus induce them to offer more attractive terms to targeted borrowers. Several motives underlie these programs. Where lenders incur high information costs in assessing default risks for a large number of potential borrowers of small amounts, they may tend to set high premiums on all loans, or even to refuse to lend regardless of risk. For example, banks and their depositors may resist making loans to students who could easily leave the area without repaying or could not offer collateral even if they remained. Federal guarantees against nonrepayment would tend to expand investment financing for high-paying investment by creating markets where high information costs or poor risk-management opportunities limit commercial activity, and thus could raise the value of national investment above that which would otherwise be undertaken, by increasing the range of feasible choices. Thus guarantees that absorb some information and risk premiums may add to returns on national capital in the same way as cash subsidies for the same investments. The federal share of private investment financed with guaranteed credit is appropriately measured by the (estimated) cost of the private insurance that would just induce the lenders to offer the same terms to borrowers.4/

4. For a discussion of the issues in measuring resource transfers under federal credit programs, see Congressional Budget Office, *An Analysis of the President's Budgetary Proposals for Fiscal Year 1988* (February 1987), Chapter VI.

Grants. The third type of investment subsidy--grants to individuals and to state and local governments--is similar to credit assistance in that grants lower the local cost of investment. But the assets constructed or purchased are owned and maintained by states and localities, and outlays for grants count as federal investment only if the subsidies they provide result in additional capital formation. Here, as with other incentives, the evidence is mixed, but generally does not suggest a large boost to investment. Students of public finance have for more than a decade found that federal capital grants to states and localities increase their capital spending by less than the face value of the grants. Recent studies have generally concluded that the ratio is no more than around 30 percent to 40 percent.5/ This means that an extra dollar in federal grants will increase national investment not by a dollar but by only about 30 to 40 cents. The remainder represents an income gain to states and localities.

Subsidies in the form of transfers to individuals and households also appear to add little to overall investment totals. Studies of the extent to which student loan assistance, for example, induces more high school graduates to enroll in college show mixed results. Interpreting these results is also complicated--first, because they are usually based on data from high school graduates who have already applied for college entrance, and second, because they rarely distinguish the source of aid. Taken together, the studies of education aid suggest that decisions to attend college are largely determined by family and personal considerations and that the influence of financial assistance is at best small; one representative study estimates, for example, that universal aid (at the average level for assisted students) would raise college enrollments from 46 percent of high school graduates to only between 49 percent and 56 percent.6/ Most federal training assistance is also provided through states and localities, but its impact on levels of national training and retraining in work force skills is unclear.

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5. The impact of federal grants to states and localities on nonfederal spending for physical facilities is discussed in more detail in Congressional Budget Office, *Federal Policies for Infrastructure Management* (June 1986).

6. Gregory A. Jackson, "Financial Aid and Student Enrollment," *Journal of Higher Education*, vol 49, no 6 (1978).

DEPRECIATION RULES

Investment in each budget cycle adds new capital, but at the same time the existing capital stock is being worn out by use, age, and obsolescence. Unless the annual additions exceed depreciation on existing assets, no net additions to the capital stock result. Tracking the effects of federal investment therefore requires not only evaluating additions to assets but also developing measures of capital consumption (depreciation).

All depreciation deductions are to some extent arbitrary. In business accounts, they are based on the principle that using assets reduces their remaining store of services and that the costs of those reductions should be reflected in production costs. But except for the partial information from secondhand asset sales, the extent of that exhaustion is not observable. New, nearly new, and old buildings and machinery often perform at about the same apparent efficiency. Furthermore, the value of a nearly new machine may be suddenly eroded by a technical change in process or a change in buyers' tastes that reduces demand for its product. In charging off depreciation, therefore, firms use accounting rules that reflect practices in their industry, tax rules, and a host of other factors including expectations about used asset prices, demand, and technological obsolescence.

No such practices, rules, or expectations establish obvious precedents for measuring the depreciation of public capital. Moreover, there are no clear parallels between federal and private business activity on which to base depreciation rules. For example, government accountants cannot often rely on used asset prices from secondhand markets to help set depreciation policies. In principle, one could estimate appropriate depreciation allowances from the contributions public capital makes to production, but this is complicated by its public use. The income against which public depreciation should be charged is not federal "income" but the income firms derive from using the capital stock. Depreciation of a dam, for example, is not properly deductible from federal tax revenue but from the income of farmers who use dam water to grow crops, because it is part of their inputs and should be covered by the prices they receive for their production. But often dams also provide water to towns; water flowing through dams turns turbines that generate electricity; and dam structures protect

downstream property from the threat of floods. No obvious choice among the depreciation practices used in farming, water and power supply, real estate, or flood insurance presents itself.

No practice exists for depreciating human or intangible capital. It is difficult to establish parallels with physical capital formation and the deterioration of physical stocks that would justify simply using business depreciation methods. Whereas machinery or a building is put into service on a specific date, the development of human and intangible capital in such fields as teaching, medical care, and research is an ongoing process. Furthermore, the asset created (skill, knowledge) persists undamaged and may be enhanced by use; only its earning power eventually wanes. Thus there is neither a clear starting point for depreciation nor an obvious rate at which these assets should be written off. Moreover, no depreciation rate could be uniform for all activities or occupations, and using broad averages would oversimplify the effects of shifts in the work force structure.

The approaches to measuring net changes in physical and other capital used in this study are described below.

Physical Capital

Failing a clear choice, this study has adopted two ways of measuring net investment in physical capital that broadly correspond to business practices in accounting for depreciation:

- Making equal deductions from investment over assets' service lives (the so-called straight-line method); and

- Deducting asset values from investment only at the end of their service lives.

The first gives a measure similar to NIPA measures for other sectors; the second results in a measure sometimes called gross investment net of retirements. Each has its advantages. The first, deducting depreciation in equal installments, has the advantage of simplicity, but it is not necessarily appropriate in all cases. A 100-year dam, for example, is not twice as productive in its first year as in its fiftieth. Many large physical assets provide "as new" service for most of their

lives, and, with proper maintenance, remain in good service condition until replaced.

The alternative net investment measure therefore assumes that assets remain in near-new condition until close to the end of their lives, and then deteriorate rapidly. Since the choice of this decay point is arbitrary unless continual surveys are made of the assets' condition, the second measure used ignores changes in services from assets until they are withdrawn from use altogether. It thus combines the advantage of simplicity with that of better reflecting service efficiency. For this analysis, assumptions as to service lives, asset replacement rates, and decay of capital input are those used by the Bureau of Economic Analysis (BEA) in compiling its data series on the nation's reproducible wealth.7/ Details are shown in Appendix A. The effects of varying these assumptions are also shown for key investment series.8/

Human and Intangible Capital

Measuring net additions to human and intangible capital raises somewhat different issues. As noted earlier, there are no estabished practices in business accounting that could be used as models. Some help may be found in the fields of growth accounting and technical change. The guiding principle is the same as for physical capital--changes in net stock should reflect changes in the amount of capital services available for producing national income. Four types of adjustment between gross investment and net wealth increases are needed.

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7. For definitions and methods, see Department of Commerce, Bureau of Economic Analysis, *Fixed Reproducible Tangible Wealth in the United States, 1925-1985* (June 1987). Data series are published and updated from time to time in the Commerce Department's *Survey of Current Business*.

8. The BEA also provides data on net stock based on a rapid decline in asset values over the last few years of service, rather than a sudden withdrawal at the end of service life. Net investment in this series lies between, and shows similar trends to, the two series presented in this report. Independent estimates of state and local investment that assume depreciation will mirror prices of used private assets, and that generally shorten service life assumptions, produce a net investment series for public capital that is also within the range, and with the same trends, as these estimates. See Michael J. Boskin, Marc S. Robinson, and Alan M. Huber, "New Estimates of State and Local Government Tangible Capital and Net Investment," Working Paper No. 2131 (New York: National Bureau of Economic Research, January 1987).

Consumption versus Investment. First, separating purchases of goods for consumption from purchases of investment goods can usually be done fairly clearly. In education, health care, and research spending, however, consumption and investment elements may be mixed in the same transaction. A net investment series has to exclude the consumption shares. Kendrick, for example, excludes half of health care spending from human capital formation, treating it as consumption, although his choice of the proportion is arbitrary.9/ Kendrick also includes all education spending as investment, but recognizes that much education is direct consumption and that education enhances many leisure activities.

For health care, developing a series for investment in human capital seems particularly susceptible to arbitrary assumptions. Choices of medical treatment seem less likely to be made with a view to their income effects than to improvements in general health and personal well-being. Education, on the other hand, is commonly undertaken with job prospects or career moves in mind; and research programs, even when they involve much experimentation, are eventually expected to generate fruitful innovations. For lack of a way to disentangle consumption and investment elements, this paper offers only broad indicators of investment in human capital.

In the field of research and development, the need for consumption adjustments to separate investment from other spending seems likely to be small. Rather, data on intellectual investment must necessarily ignore the vast but uncountable contribution of on-the-job experience (learning-by-doing) to industrial and commercial innovation. Formal research and development activity is thus a convenient, but not a comprehensive, measure of investment in scientific capital. A different type of deduction may be necessary to exclude from the capital formation series R&D spending aimed at noncommercial innovations. In particular, many analysts argue that military performance specifications for new equipment and systems are now so greatly different from those that would support successful commercial adaptations that the development portions of military R&D programs no longer contribute to commercial innovations. This implies that military devel-

9. See John W. Kendrick, *The Formation and Stocks of Total Capital* (New York: National Bureau of Economic Research, 1976).

opment expenditures should no longer be thought of as sources for commercial spinoff innovations (and thus part of the nation's expanded capital base), but should be classed with other noncapital programs within military spending. Furthermore, it has been argued that, because of their different objectives, military programs are an increasingly inefficient way to seek commercial innovations.10/ Thus, even allowing commercial spinoffs from military development programs, the commercial value of the knowledge may be less than that from the same spending in other R&D programs.

Time Lags. Time lags between investment and changes in the productive capital base are longer for human and intangible capital than for plant and equipment. Kendrick uses the age of 28 years as the "maturation age" for education investment, and the age of 18 years for health investment.11/ At 28 years, his data show, the earning potential of a person's education is maximized. Under his method, all spending is accumulated (like "work-in-progress" for construction projects) until age 28 (or 18) when returns on the investment begin to be realized. Because of the longer gestation period, an investment in education may appear to have relatively smaller effects on work-force skills than a physical investment offering the same return. But, since only broad indicators of investment in human capital are shown, no adjustments for these time lags are made in this study.

Measured Output. Since the aim is to clarify changes in national income, components of human or intangible capital that do not contribute to output changes as measured should be deducted from investment. In principle, research applied in nonbusiness activity, and investment that aims at introducing new products, should be excluded in favor of investment that increases quantity or lowers costs of production. New products carry quality changes that are not easily measured in national output data, so that including their related

10. Nathan Rosenberg, "Civilian Spillovers from Military R&D Spending: The American Experience Since World War II" (paper prepared for presentation at the Conference on Technical Cooperation and International Competitiveness, April 2-4, 1986, Lucca, Italy). This may also be true for basic and applied research that may be subjected to secrecy restrictions if conducted by military scientists but not if conducted by private scientists.

11. Kendrick, *The Formation and Stocks of Total Capital*.

research overstates the size of the capital base needed to generate recorded income levels.

Views differ as to how much of federally funded research is directly associated with measured income growth. One analyst has estimated that only half of R&D spending affects productivity as measured, and that only half of that amount adds to the net stock of productive knowledge. He excludes R&D spending for defense, space exploration, health, and environment, and also for industrial applications (such as computers) that aim at quality change.12/ On the other hand, industry analysts underscore the difficulties of identifying what will be discovered in any experimental project, or how any discovery will make its way to the production line. All basic research contributes generally to knowledge, with no boundaries on the potential applications of its findings. Applied research, though oriented to a particular outcome, ranges fairly widely for solutions. 13/ Only in the development stage do researchers seek particular and dedicated solutions that may or may not be adaptable by other users. For these reasons, this study presents net additions to R&D capital in two series. The first excludes development expenditures for defense, space, health, and environment, and the second makes no deductions.

Depreciation. The net additions to capital should also reflect capital used up in production. In knowledge-oriented investment--that is, basic and applied research--depreciation, in the sense of a gradual withering away of the assets, is generally not taken account of. Knowledge, once found, remains intact, is not eroded by production processes, and therefore need not be replaced. Once the accountant has adjusted investment streams for consumption, time lags, and quality factors, net stocks are affected further only by retiring R&D assets. In these estimates of intangible investment, development expenses are written off evenly over a 10-year period beginning five years after the expenditure was incurred.

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12. Zvi Griliches, "R&D and the Productivity Slowdown," *American Economic Review*, vol. 70 (May 1980).

13. Some analysts class applied research with development, as product-oriented activity, rather than with knowledge-seeking basic research.

Human capital is exhausted with age, or when workers retire, but such retirements (in a human capital accounting framework) reduce capital values that are wholly within the household sector. Moreover, the share of such retirements traceable to past federal education and health programs is unknown, although estimates of retirements have been compiled on a national scale. No deductions can be made from federal health, education, or training subsidies to adjust for (uncounted) retirements of workers benefiting from federal programs. Reductions in the training capital of federal employees, however, are taken account of as trained employees leave their jobs.

Net Additions from Subsidies and Grants

On detailed points, converting gross measures of the investment effects of grants and other subsidies to net measures would follow the procedures outlined above for physical, human, or intangible capital according to the type of investment financed. Thus a grant for highway construction would be treated as generating an addition to net capital in accordance with the measurement rules for physical capital, and a guaranteed student loan would be treated according to the rules for human capital formation.

A more important question is where these additions are to be credited. On a national level, attributing subsidized investment to any sector does not alter overall totals as long as double counting is avoided. Including the gross contributions to subsidized investment with federal investment acknowledges the financing source for the subsidies. On a sectoral level, however, contributions to net national saving and investment conventionally reflect who has the care and custody of the assets. This study therefore credits net investment effects under subsidies to the investing sector--state and local governments or private businesses and households--rather than to federal budgets. It shows net federal and national contributions to capital formation after crediting subsidized investment to the sectors that benefit from it.

CHAPTER IV

DIRECT FEDERAL INVESTMENT

This chapter estimates direct federal investment activity on the basis of the concepts used in the national income and product accounts (NIPA) to define investment by businesses and households. Under these principles, federal physical investment is seen as heavily concentrated in large construction projects--dams and other water resources improvements, and heavy engineering plant. Apart from occasional spurts of residential investment, direct federal investment in other types of capital is small.

The estimates of net physical federal investment in this report are based on Bureau of Economic Analysis data that are part of the official series on national capital stock. Thus, federal capital spending is, in some official data, already counted as additions to the nation's "capital," although changes in that government capital stock are not counted as part of national investment. Since the federal investment is small, however, including it in national investment would not markedly shift estimates of national saving as a percent of net national product (NNP).

The principal difficulty arises in estimating the depreciation on past investments. The range of depreciation measures that would reflect federal capital consumption under reasonable estimates would lead to measures of net investment that vary by as much as one-third in some categories. Rate of return estimates also suggest that construction costs may overstate the investment values of current federal projects.

MEASURING PHYSICAL INVESTMENT--THE NIPA STORY

Federal investment under the strict application of national income accounting principles would include only physical assets financed and owned by federal agencies. Taken as a whole, such net federal

contributions to physical capital have been $4 billion a year or less (at 1982 prices) since the mid-1970s, depending on the choice of depreciation method. Since 1978, federal purchases of physical assets have hovered around $13 billion a year, and estimated allowances for assets taken out of service have been around $9 billion annually. Thus if depreciation is charged only when assets are withdrawn (the lower of the two measures used), net federal investment could be estimated at around $4 billion a year (see Table 3). If depreciation is instead measured on a "straight-line" basis (by deducting equal annual installments of the value of the assets over their useful lives) net investment over the same period appears to have fluctuated around zero (Table 4). Thus the use of NIPA concepts to measure federal investment would not markedly change current estimates of federal saving and of the federal budget's impact on net national saving and investment.

When using the national income accounting format employing the strict "physical plant and equipment" definition, the largest components of federal investment are dams and other structures constructed under federal water resources and energy programs; military buildings and other fixed military facilities; and industrial plant, particularly the large industrial equipment used principally in the construction of military ships and aircraft. Trends differ among these components:

- Except in times of sudden bursts of military spending--as during the Second World War and in the strategic expansion lasting from the early 1950s to the early 1960s--federal spending on military facilities (other than strategic vehicles and weapons) has been less than either of the measures of depreciation used in this study. The small positive net investment now evident in Table 3 follows a 46 percent spending boost between 1982 and 1986, and is the first net addition to capital under either measure since 1976. Thus the measured contribution of military programs to net capital formation has usually been negative.

- Net investment in water and energy structures follows cycles of about 15 years, with falling net spending between 1978 and 1985 representing the downward phase of the last cycle, pending the program's reauthorization in 1986.

- Net federal investment in heavy industrial equipment, reflecting federal purchases of the military ships, aircraft, and weapons it is used to construct, increased rapidly in 1982 and 1983. Equipment purchases by federal enterprises have been on the upswing since 1982. However, because of large write-offs under both methods, net investment remains negligible, and similar to the typically negative levels throughout much of the 1970s.

Military Investment

The persistently negative net investment in military structures except in emergency periods does not necessarily reflect any inadequacy in military facilities. Rather, it follows from the pattern of military affairs. During national crises, military facilities are rapidly expanded, both by commandeering private facilities and through crash construction and expansion programs that lead to sharp peaks in military investment. These peaks account for the higher overall federal net investment rates shown in Figure 2 for 1949 through 1966. During World War I, real annual investment spending on military bases was 40 times more than the average of the previous five years; during World War II, spending rose to a level 18 times above prewar averages; and in the arms buildup of the 1950s, yearly investment spending was 24 times that of the late 1940s. These peaks build capacity in bases far beyond peacetime needs, and at the same time provide facilities that may become outdated as technologies change. In many cases, book values for these assets may greatly overstate their real usefulness for current military purposes--in some cases because they exceed peacetime requirements, and in others because they are militarily obsolete. A military accounting of these assets, therefore, would probably allow faster write-offs of wartime assets. Moreover, military managers may replace the services of older assets by renting or leasing from private investors rather than investing directly, so that the condition of owned facilities may in some cases not be typical of the facilities in use.

From a civilian point of view, however, the persistent negative net investment in these assets means that they are increasingly irrelevant to the national productive capital base. Nominally, all are tradeable assets--hangars, offices, and so on--that, at least in prin-

ciple, could be leased, and excess capacity sold. The fact that they have not been sold to other users (as was done with wartime factories, for example) indicates that in practice their transferability to civilian uses is limited. This may be because of the costs of converting them to commercial and private use, or, probably more commonly, their location in places where use by private owners would impede military operations. While from a national accounting point of view, investment in military buildings and facilities is a federal counterpart of

TABLE 3. NET FEDERAL PHYSICAL INVESTMENT AFTER DEDUCTING ASSETS WITHDRAWN FROM SERVICE
(NIPA basis, in millions of dollars, at 1982 prices)

	Structures					
	Civilian Nonresidential					
	Buildings			Other Civilian Nonresidential		
Year	Industrial	Hospital and Education	Other	Highways	Conservation and Development	Other
1949	574	633	359	251	3,315	126
1959	379	171	519	355	3,219	135
1969	-379	242	-37	586	2,830	46
1970	-663	327	-73	635	3,066	78
1971	-519	374	-43	670	3,405	125
1972	-893	242	-122	661	3,417	348
1973	-820	275	-22	536	3,572	452
1974	-945	257	-140	375	3,646	329
1975	-1,099	288	180	412	3,560	303
1976	-1,147	306	-81	468	3,602	327
1977	-1,186	365	966	540	3,597	327
1978	-1,564	416	414	479	4,346	324
1979	-1,526	382	487	490	4,004	222
1980	-1,463	424	455	337	3,868	176
1981	-1,676	468	497	620	3,564	119
1982	-1,550	365	156	559	2,966	132
1983	-1,489	334	365	376	2,719	89
1984	-1,364	366	578	397	2,465	132
1985	-1,265	382	730	295	2,284	-97
1986	-914	404	800	227	2,091	289

SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

household home ownership since it avoids rental payments, it does not bulk large enough to be significant.

Water and Energy Resources

Fluctuations in net investment in the conservation and development of water and energy resources reflect funding patterns. Spending,

TABLE 3. (Continued)

Structures (Continued)		Equipment		
Residential Investment	Military Structures	Industrial	Other	Net Federal Investment Type 2 a/
-576	-54	1,258	-785	5,102
1,874	4,147	1,451	190	12,440
315	104	1,111	947	5,765
400	-261	784	377	4,671
1,046	673	1,078	-270	6,541
1,974	260	-263	1,268	6,894
1,777	-158	141	-46	5,706
1,492	-931	-226	-30	3,827
356	272	-384	-431	3,459
177	473	-288	-581	3,256
468	-562	314	-845	3,984
799	-797	55	-784	3,688
328	-1,732	-1,478	-520	657
664	-430	129	-23	4,137
595	-326	336	-329	3,868
480	-1,379	807	-1,446	1,090
948	-673	1,943	-1,320	3,292
1,254	-1,392	-59	-790	1,588
1,329	206	-202	-608	2,189
1,886	872	-95	-829	4,730

a. Net Federal Investment Type 2 is gross investment less the value of assets withdrawn from service in each year.

following periodic authorizations of these large projects, gradually rises until most construction nears completion and then tails off until a round of new project authorizations. These lumpy patterns are also reflected in retirement and depreciation schedules. Falling net investment in this category between 1978 and 1985 represents at most a longer-than-usual tailing-off period rather than a long-term decline in real investment, especially in view of the new project authori-

TABLE 4. NET FEDERAL PHYSICAL INVESTMENT AFTER DEDUCTING EQUAL ANNUAL AMOUNTS FOR DEPRECIATION (NIPA basis, in millions of dollars, at 1982 prices)

	Structures					
	Civilian Nonresidential					
	Buildings			Other Civilian Nonresidential		
Year	Industrial	Hospital and Education	Other	Highways	Conservation and Development	Other
1949	112	595	122	162	2,295	38
1959	-734	80	347	222	1,816	61
1969	-887	105	-160	369	1,012	-54
1970	-923	185	-247	411	1,240	-8
1971	-683	228	-163	437	1,619	35
1972	-1,033	95	-61	422	1,543	244
1973	-664	122	137	290	1,665	373
1974	-757	108	-28	126	1,696	235
1975	-920	131	76	161	1,650	228
1976	-878	144	-220	216	1,665	255
1977	-835	206	817	282	1,717	223
1978	-787	246	233	217	2,478	218
1979	-734	221	156	227	1,964	82
1980	-683	250	107	72	1,836	70
1981	-630	291	109	352	1,499	-21
1982	-578	191	-164	288	895	-2
1983	-529	148	19	103	686	-6
1984	-485	196	231	122	416	-5
1985	-444	198	374	24	257	-165
1986	-430	220	406	-44	125	172

SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

zations in the Omnibus Water Resources Development Act of 1986. Net investment in 1986 was up.

Spending on physical capital in this category illustrates the need for appropriate measures of investment valuation and capital consumption (depreciation). On the one hand, dams and other heavy structures are constructed to last virtually indefinitely. Moreover, leaving aside pumping machinery or turbines that are included in

TABLE 4. (Continued)

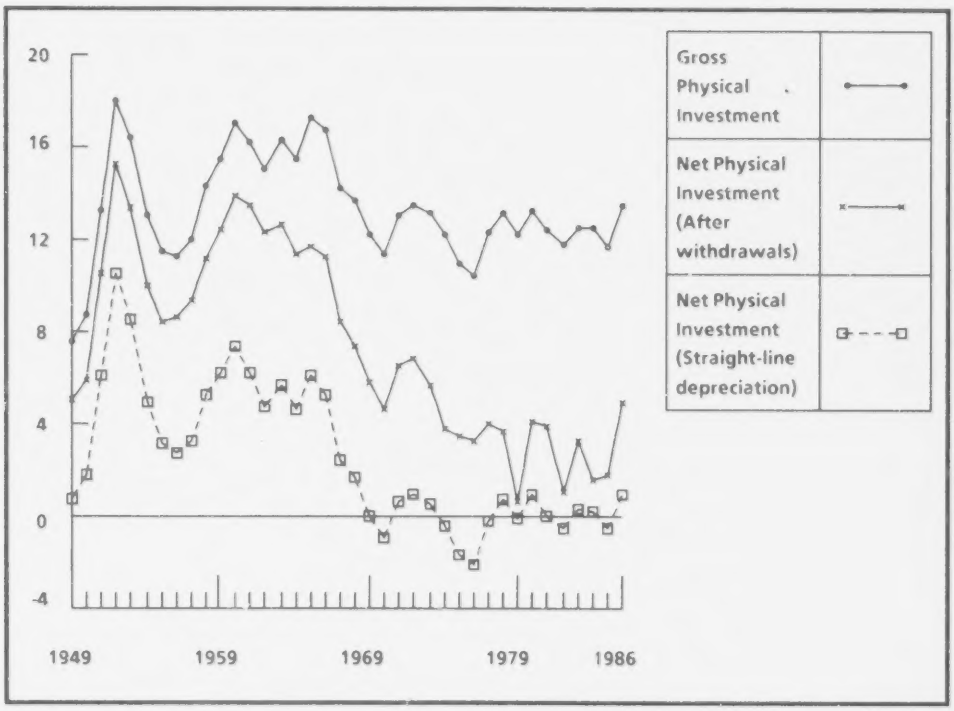
Structures (Continued)		Equipment		
Residential Investment	Military Structures	Industrial	Other	Net Federal Investment Type 1 a/
-755	-2,274	1,010	-553	753
1,673	1,919	585	224	6,193
19	-1,464	847	211	-3
117	-2,098	853	-430	-900
741	-1,724	1,038	-921	607
1,650	-1,671	-841	555	903
1,438	-1,608	-444	-756	552
1,118	-1,862	-518	-544	-427
-31	-1,269	-785	-900	-1,659
-182	-1,577	-744	-763	-2,084
81	-1,675	-288	-701	-174
411	-1,715	-5	-580	717
-47	-1,928	170	-236	-125
285	-1,574	88	465	915
216	-1,895	-15	112	17
116	-1,476	1,019	-861	-572
553	-983	938	-656	272
832	-841	-129	-137	201
937	-519	-68	61	-212
1,486	-297	-656	192	1,173

a. Net Federal Investment Type 1 is gross investment less straight-line depreciation.

equipment investments, using water from reservoirs does not cause the dams to wear out. These considerations argue for low depreciation rates on these structures over very long lives. Economic evaluations of projects constructed by the Corps of Engineers, for example, project that users will enjoy full services for 100 years.

On the other hand, experience with large dams is limited; the major construction phase began only in the late 1920s, and estimates of useful lives and deterioration rates are still based on assumptions rather than on experience. Major dams have failed, and others have required remedial work to correct design faults that impaired their safety (as under the federal program that finances repairs to sub-

FIGURE 2. MEASURES OF FEDERAL PHYSICAL INVESTMENT
(NIPA basis, in billions of dollars, at 1982 prices)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

standard structures). Furthermore, the overall operation of a dam is dependent on other parts of the structure--sluice and lock gates, for example--that have considerably shorter lives than the dam itself. This argues that, to preserve the economic usefulness of dams, depreciation charges against the incomes of water users should be large enough to allow a fairly rapid build-up of reserves to provide for rehabilitation or remedial work. For example, the Bureau of Economic Analysis estimates that are used in Tables 3 and 4 write off capital expenditures over a period of only 60 years.

Estimates of net investment in these structures differ considerably under the two approaches to depreciation, but at a maximum they would not put net federal investment in physical assets outside the $4 billion annual upper limit mentioned earlier (see Table 5). The evidence, however, tends to favor a longer life than 60 years. The reauthorization of water resources development under the Corps of Engineers' programs in 1986 included mostly new or expansion projects rather than the first rush of rehabilitation work that would be expected if the projects constructed in the 1920s and early 1930s were approaching rapid deterioration. The Bureau of Reclamation's 1988

TABLE 5. EFFECT OF VARYING ASSUMPTIONS FOR DEPRECIATION ESTIMATES ON NET INVESTMENT FOR CONSERVATION AND DEVELOPMENT OF WATER AND ENERGY RESOURCES (NIPA basis, in millions of dollars, at 1982 prices)

Asset	1970	1975	1980	1985
Equal Annual Depreciation Deducted Each Year				
100 Years	2,186	2,667	2,923	1,236
60 Years	1,240	1,650	1,836	-96
Depreciation Deducted Only When Asset Withdrawn				
100 Years	3,632	4,286	4,685	3,106
60 Years	3,066	3,560	3,868	2,284

SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

budget request proposed to defer advance planning for most of the new projects and reorganize the construction program to hasten completion of long-delayed projects by deferring spending on new projects.

But the projects proposed by the Corps of Engineers cannot be thought of as substitutes or supplements for deteriorating older systems. Rates of return on rehabilitation projects are typically very high, because demand has been at high levels for many years, and because the disruption resulting from supply interruption after a dam failure would be large. Returns on the new projects are low, however. As Figure 3 shows, about one-third of the Corps of Engineers' construction budget proposal for recent projects in 1988 is for projects with negative rates of return. The benefits to users of these projects once completed--benefits in the form of higher crop yields, less damage from floods, and so on--will not repay the remaining construction and maintenance costs.1/ Another 37 percent of the projects will have returns that do not cover the projected federal cost of funds, and the next 4 percent would be unattractive at business borrowing rates. Of all the projects with returns above 10.3 percent, only three (expanding or modifying existing projects) show the very high returns typical of projects that rehabilitate or expand successful older infrastructure investments, and these projects account for less than 2 percent of the new construction efforts. An approximate market valuation for the proposed water and energy resources investments could be as low as 46 percent of the construction cost of the assets.

Managers of national systems for conservation and development of water and energy resources are not calling attention to deteriorated structures, nor are they constructing alternative systems that could be used to bolster supply from deteriorated structures. Managers of local and regional water systems, on the other hand, are finding many ways of improving the output or lowering the supply costs of existing systems--including trading water rights among users and localities and using regional management systems--so that the productivity of existing water resources assets seems more likely to improve in the future through management innovations than to deteriorate through structural failure.

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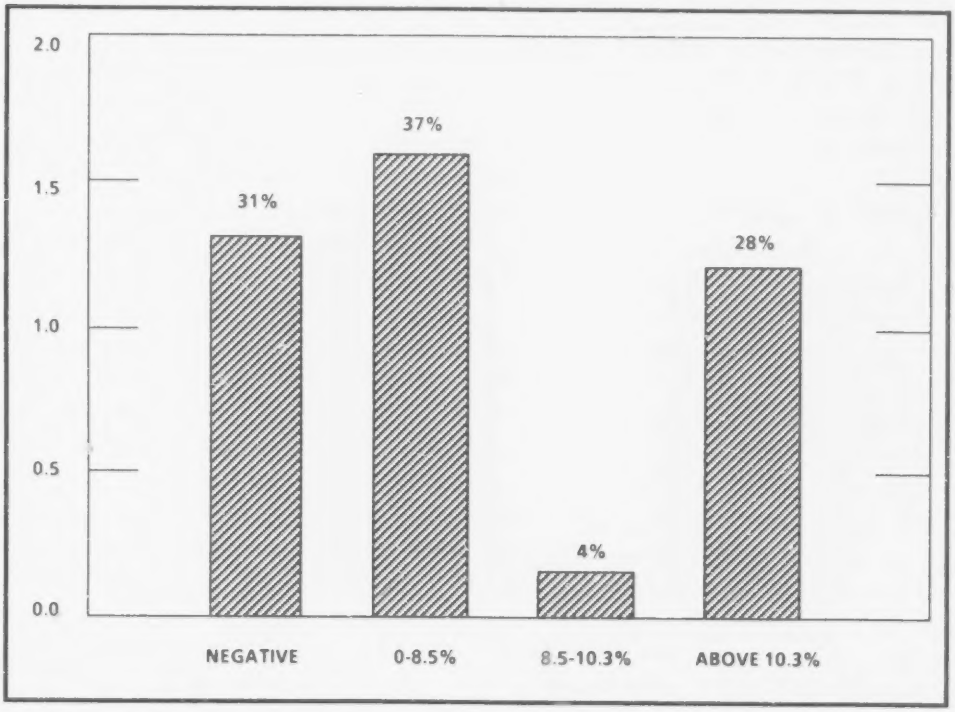
1. Based on Army Corps of Engineers, *Detailed Budget Justifications* (1987).

Industrial Plant and Equipment

The rapid increase in net investment in federal industrial plant from negligible levels (in 1982 prices) in the late 1970s to around $1 billion in 1982 and 1983 reflects the increase in military procurement in those years. These investments are mostly in heavy engineering equipment as used in shipyards and in military construction. The remainder of net federal investment in physical assets consists of fairly small programs for constructing schools, hospitals, and other public buildings, and for federal housing construction under numerous programs. Throughout much of the last decade these investments added

FIGURE 3. COMPLETION COST AND RATE OF RETURN ON RECENT WATER PROJECTS (In billions of dollars)



SOURCE: Congressional Budget Office, based on data from Army Corps of Engineers, *Detailed Budget Justifications* (1987).

NOTE: CBO's projection of the 10-year government bond rate through 1988 is 8.5 percent. Using historical relations to the AAA-corporate rate, business long-term borrowing cost would be around 10 percent to 10.3 percent.

less than $600 million a year to net capital. Following a 75 percent increase in housing construction in 1983, and a further 95 percent jump through 1986, however, net residential investment now tops $1 billion a year.

Thus federal physical investment is concentrated in heavy construction--dams and other water resources improvements, and heavy engineering plant. Apart from occasional spurts of residential investment, direct investment in other capital sectors is small. Moreover, because of low rates of return on current projects, construction costs probably overstate the value of the investments undertaken.

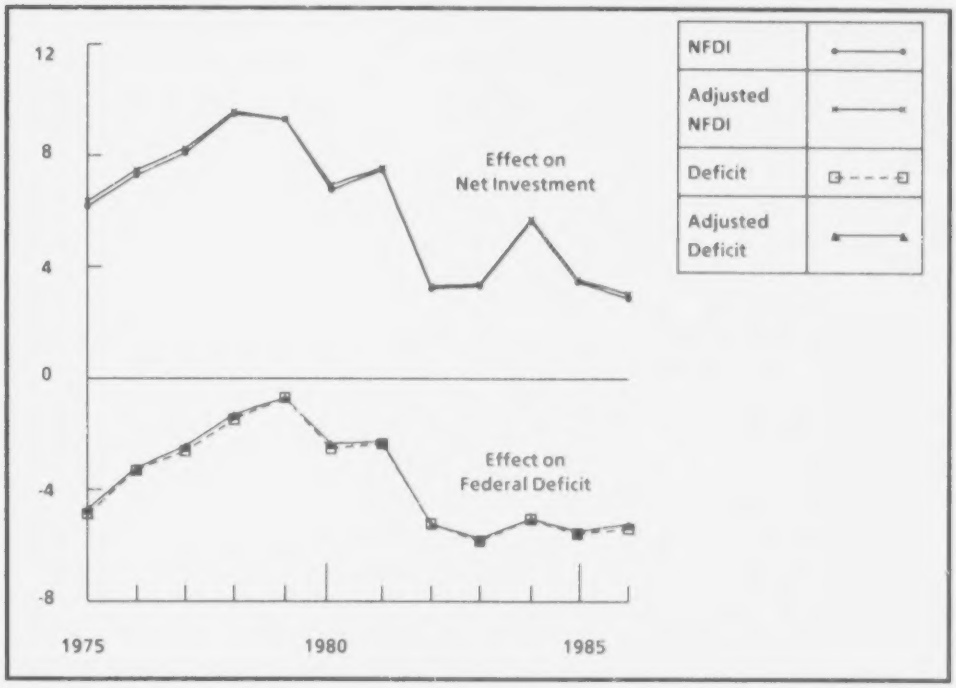
EFFECT ON SAVING AND INVESTMENT MEASURES

This chapter has shown that adjusting federal accounts for federal investment activity consistent with current conventions for national accounting of physical assets would have reduced the federal deficit at most by a steady 0.1 percent of the net national product (NNP) in the years 1980 to 1986. Adding such federal net investment to national fixed investment would also slightly raise measures of the national investment rate (as a percent of NNP) without altering the general downward trend evident in the 1980s. Figure 4 illustrates these results.

While the principle of separating federal budget accounts into capital and recurrent operations accounts is fairly clear, there is some question whether adding government physical capital to national fixed investment is warranted in measuring national totals. Any estimate of federal net investment would include many investments valued at construction cost that have low or negative rates of return, when measured comparably with the business returns of private investment, because they are intended to serve general welfare or social purposes that are not easily incorporated into benefit measures and that are not reflected in national income data.

Some analysts argue, moreover, that the value of public capital (and services) in any community is reflected in its private property

FIGURE 4. EFFECTS OF FEDERAL INVESTMENT ON NATIONAL SAVING AND INVESTMENT RATES (As a percent of NNP)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

NOTES: Adjustments for federal net physical investment are based on deducting withdrawals from capital stocks from gross investment. NFDI = Net fixed domestically owned investment.

values.2/ Thus, public investment would be reflected in private totals by its effect in raising the value of private investment purchases. On the other hand, improvements on public capital raise values for all existing as well as new private property, so that the private investment totals would tend to undercount the value of public investment in all except rapidly growing communities. National accounting does not now adjust for capital gains and losses, but adding public investment to national totals would recognize that a part of national changes in wealth (whether captured in private values or not) is attributable to expansions of public fixed facilities.

2. Charles R. Hulten and Robert M. Schwab, *Income Originating in the State and Local Sector* (New York: National Bureau of Economic Research Working Paper No. 2314, July 1987).

CHAPTER V

EXTENDING CAPITAL CONCEPTS

Under the strict interpretation adopted in Chapter IV (following NIPA principles for business and household investment), federal investment activity would add $4 billion or less to national (net) investment totals (at 1982 prices) over each of the past 10 or so years. But using the broadest interpretations, federal investmentlike activity would have added up to $60 billion to net investment in 1986. Of that amount, net investment in defense assets would have added $17 billion a year (in 1982 prices), up from negligible levels before 1978. Federal research and development programs that are designed to promote commercial innovation would have added an estimated $10 billion to $20 billion a year in net national scientific or intellectual capital; and subsidies for physical capital investment would have added a net $11 billion to $22 billion to state and local assets. Federal education and training assistance, if included, would add an additional $20 billion a year to national investment totals, unadjusted for depreciation.

The picture is somewhat different for the period 1980-1986. Overall, investment under the broadest interpretation has increased since 1980, but this increase derives from the large rise in net investment in defense assets and in spending on military research and development. Other categories have shown stable or declining activity. Neither individually nor together would the expanded investment categories be sufficient to reverse or even offset the falloff in domestic saving and investment recorded in official data.

Not all of these investments would raise saving attributed to the federal government. Because some of them are financed from federal subsidies, the saving and investment activity would logically be accounted in the sector that receives the subsidy, makes the investment, and operates, maintains, or uses the assets created. Thus federal capital grants for infrastructure would increase national investment by

raising state and local government saving and investment, and federal support for education and training would increase national human capital by raising saving and investment in households. Of the overall 2.5 percent of net national product invested in public capital under the extended concepts, only about half would be accounted as federal investment.

INVESTMENT IN DEFENSE ASSETS

Defense assets--weapons, and the ships, aircraft, and structures needed to transport, deploy, and launch them--can be considered an extension of national capital since they provide defense services over a number of years. If national defense were provided under contract with private armies, this long-lived property would be considered capital. Government defense forces might thus be viewed as alternatives to such private armies, and the weapons and associated facilities they use would form part of the capital stock.

On the other hand, even under this formulation, weapons systems could be considered inventories or stockpiles for future use, somewhat like a firm's supply of raw materials. Their claim as fixed assets rests on the deterrence they provide without actually being put to use. In time of war, counting these assets as fixed capital would imply that the nation was poorer to the extent that they were used up. Counting defense assets as inventory, however, would require their periodic revaluation--much as producers' stocks are revalued to reflect changes in their potential contribution to profits.

Thus, to the uncertainties already seen in estimating depreciation on public assets must be added the difficulty that, in the case of defense assets, the amount and value of the services the assets produce (and the public consumes) are unknown. Capital consumption for defense cannot be related to the contribution of assets to output but only to characteristics of the assets themselves. If regarded as inventories, defense assets would be added to stocks when purchased and would enter annual federal spending accounts only when withdrawn or used. Capital consumption would then be measured in terms much like the second measure used for federal assets in Chapter IV. In that case, defense procurement of weapons systems would not, in ordinary

years, add to measures of federal spending or deficits. But weapons systems are subject to technical obsolescence and, after a few years, may not offer the same level of service as when new. To the extent that new purchases restore a diminished technical edge, or respond to hostile actions, they may merely replace value lost to the inventory. Moreover, many of the facilities--ships and aircraft, for example--undergo physical wear and tear while in service, which argues for estimating regular annual allowances for capital services.

Net Spending on Defense Assets

Between the end of the Korean war and 1978, net investment in defense assets was negligible. This measure treats defense assets, like business capital, as subject to physical wear and tear, and depreciates them uniformly over the service lives shown in Appendix A. During the major military buildup of the 1950s and early 1960s, net defense investment maintained a rate of around $5 billion a year (in 1982 prices) for only three years. In many other years during the period, net investment was negative. Table 6 shows net investment based on deducting straight-line depreciation; Appendix Table B-2 shows gross investment in defense assets.

In the late 1970s, however, net investment began to rise, going from about $7 billion in 1978 to $21 billion in 1982. Net investment in subsequent years has been lower, but the total during 1982-1986 exceeded that of the earlier largest peacetime defense buildup from 1960 through 1966 by a factor of four.

Implications for National Saving and Investment Data

If purchases of defense assets were treated as investment in national income data, measures of federal saving--though remaining unchanged for much of the postwar period--would be increased from current levels by as much as 0.6 percent of net national product, and domestically owned fixed investment would rise from 2.9 percent of NNP to 3.5 percent. This adjustment, though it would reduce the federal deficit measure by around one-seventh, would not alter the general downward trend of national investment levels. Under the revised

definition, the falloff in national investment from its rates above 8 percent of NNP in the 1970s remains steep (see Figure 5).

INVESTMENT IN INTANGIBLE CAPITAL

Investment in intangible or intellectual capital--spending on research and development activity--can claim to be part of national investment because the resulting knowledge may alter products and production

TABLE 6. NET INVESTMENT IN DEFENSE ASSETS
(NIPA basis, in millions of dollars, at 1982 prices)

Calendar Year	Net Equipment Procurement	Net Silo Construction	Net Investment Defense Assets
1949	-41,779	43	-41,779
1959	-814	61	-685
1969	-1,338	-54	-1,357
1970	-1,491	31	-1,538
1971	-2,625	56	-2,679
1972	2,244	67	2,275
1973	-772	60	-716
1974	-2,157	52	-2,090
1975	2,155	2	2,215
1976	3,751	-81	3,803
1977	1,652	-89	1,654
1978	7,336	-89	7,255
1979	9,692	-88	9,603
1980	8,875	-88	8,786
1981	9,757	-88	9,669
1982	20,667	-87	20,579
1983	14,850	-87	14,762
1984	11,105	-87	11,018
1985	15,777	-87	15,690
1986	16,881	-85	16,796

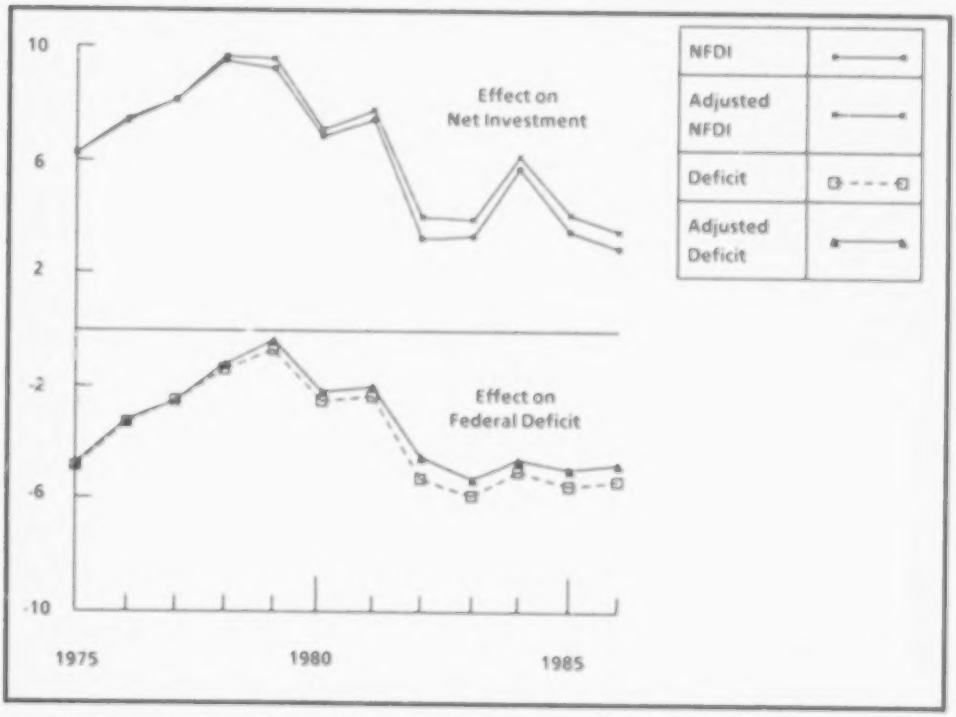
SOURCE: Congressional Budget Office based on budget data, and Bureau of Economic Analysis.

NOTE: Based on straight-line depreciation.

processes. Finding and spreading new knowledge and technologies may create new income over long periods.

Rigorous standards of what to include, however, are difficult to devise. Research and development expenditures are relatively loosely defined compared with the outlays on construction or fixed equipment that constitute physical investment. Classifying research and development as investment would transfer scientists' and other researchers' salaries and laboratory costs from operations to investment.

FIGURE 5. EFFECT OF INVESTMENT IN DEFENSE ASSETS ON NATIONAL SAVING AND INVESTMENT RATES
(As a percent of NNP)



SOURCE: Congressional Budget Office based on data from the Bureau of Economic Analysis.

NOTE: Adjustments are based on net investment after deducting equal annual amounts for depreciation.

NFDI = Net fixed domestically owned investment.

(Spending for laboratories themselves and for major equipment used in research and development would be classified as investment in physical capital.) Research and development inevitably include unsuccessful as well as successful projects; but it is not easy to establish the success and commercial usefulness of such activities until well after their completion.

Research and Development

The two measures of net investment through research and development that are proposed in Chapter III would, if included in national investment totals, show divergent trends. As Table 7 indicates, despite a rapid increase in resources for federal research and development programs in the last decade, resources for net federal investment in those areas of research with the greatest commercial or industrial potential have remained unchanged at about $10 billion a year--apart from a bulge in energy development spending during 1978-1981.1/ Measures of net investment through all federal research and development programs, on the other hand, show a rapid increase from negative levels 10 years ago to around $20 billion a year. These measures reflect write-offs of around $5 billion in 1986 in commercially oriented programs, and about $26 billion overall, for past development efforts that have become obsolete or have been fully embodied in production.

The difference between the two series in Table 7 reflects several influences. First, the switch in the space program from a developmental to an operational phase in the late 1960s and early 1970s led to a greatly reduced space research program over the past 20 years as compared with the intense development activity of the sixties. During this period the usefulness of the vast array of findings from the 1960s

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1. Estimates of net R&D are based on National Science Foundation data for spending and on writeoffs for past development as set out in Chapter III. The "commercially oriented" category includes all federally funded research and development except development expenditures under military, space, health, and environment research programs. As discussed in the last chapter, these are the programs that analysts of technical change identify as most likely sources for commercial innovation spinoffs that could increase national income by reducing production costs. Gross spending data corresponding to the net investment series are shown in Appendix Tables B-3 and B-4.

in fostering new products or processes in space and nonspace areas has gradually dwindled. Space research in the last 10 years has not offset this decline; the space program and users of its research findings have been largely living off the 1960s effort. As measured here, net additions to the scientific or knowledge base for industrial innovation from the space program in the past 10 years have been negative. This would imply that federal efforts to find innovative production processes and products are less than sufficient to offset the decline in technologies that are becoming obsolete.

Some caveats should be entered here. First, federal and private research are more often complementary than competing, and federal programs are sometimes thought to be in the riskier fields. Thus, having demonstrated feasible space flight in the 1960s, space research may now be much more evenly spread between public and private activity. Moreover, federal spending on research and development cannot capture the vast additions to knowledge gained by astronauts in operational missions, so that the investment base in any particular program against which earlier development might be written off could well be greatly understated. Second, unlike physical or even human capital, the assets created in intangible investment are not owned by the investing sector but exist in the public domain. Thus it is somewhat artificial to estimate net investment series for research and development either in different economic sectors (federal or private) or in different programs (health, space, and so on). Moreover, whereas negative investment has observable results in other fields--say, deteriorating structures or declining skill levels--it is difficult to devise tests of the subtle changes in the national capacity to seek innovations and technical change that would follow from negative investment in intellectual capacity. Under the alternative net measure shown in Table 7, overall net scientific investment has not been negative at any time. Some analysts computing intellectual capital stocks do not write off development at all, so that their estimates of net and gross investment (gross investment is shown in Appendix Tables B-3 and B-4) are the same. There is no verifiable way to distinguish which of these three measures reflects current changes in national capacity for innovation.

A second difference in the two series in Table 7 is that the increase in net federal investment in overall scientific or intangible capital reflects largely an expansion of efforts to find applications from earlier

civilian and military research to national defense. Military R&D programs are now approximately 90 percent for development and 10 percent for basic or applied research. Most of the rapid rise in military research and development since the late 1970s has been in development programs that seek to apply known technology to military equipment and systems. Military programs seeking knowledge through basic and applied research have not seen the same increase; spending on these has remained around $3 billion a year (after correcting for price changes) since 1975. Defense programs, however, are by far the largest and fastest growing, increasing from 50 percent of federal research and development in the mid-1970s to 70 percent now.

TABLE 7. FEDERAL AND PRIVATE NET INVESTMENT IN INTELLECTUAL CAPITAL THROUGH RESEARCH AND DEVELOPMENT
(NIPA basis, in millions of dollars, at 1982 prices)

	Federal Science, Industry, and Commerce Applications						
	Federal R&D			Federal Research			
	Energy	General Science	Agriculture, Transport, and Other	Military	Space	Health	Environment and Natural Resources
1960	n.a.	n.a.	n.a.	4,374	1,222	1,354	344
1969	n.a.	n.a.	n.a.	4,597	2,275	2,769	642
1975	287	983	1,881	2,888	1,352	2,886	864
1976	1,051	1,045	1,417	2,722	1,783	3,025	807
1977	1,592	972	1,461	2,731	1,824	2,446	751
1978	2,107	969	1,573	2,808	1,744	3,486	819
1979	2,679	991	1,300	2,764	1,788	3,800	1,007
1980	2,431	957	1,181	2,988	2,386	3,958	964
1981	2,301	943	955	3,054	1,582	3,962	832
1982	1,436	960	646	2,923	935	3,992	777
1983	729	939	538	3,079	1,104	3,960	765
1984	771	1,016	681	2,973	1,296	4,021	733
1985	853	1,077	770	2,766	742	4,338	716
1986	-508	1,200	824	2,843	745	4,533	727

SOURCE. Congressional Budget Office, based on data from the National Science Foundation and the Office of Management and Budget.

But this expansion in military R&D has not been at the expense of federal support for industrially or commercially oriented research and development. Spending on basic and applied research in programs other than defense or space has been fairly stable at around $6 billion to $7 billion a year (in 1982 prices) since the late 1960s, about half of it for health and medicine. Virtually all of this represents net investment in scientific capital. The remainder of the $10 billion in net investment includes small amounts of military and space research, and net development under energy and other federal R&D programs.

TABLE 7. (Continued)

Federal Industrial/ Commercial R&D	Other Federal Development				All Net Federal R&D	Net Private R&D
	Military	Space	Health	Environment and Natural Resources		
n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	22,841
11,140	-7,355	-5,792	607	162	-1,238	15,642
11,850	-7,516	-6,652	454	121	-1,742	16,240
11,776	6,599	7,182	259	37	-1,708	16,718
13,506	-5,666	-7,437	342	55	799	18,009
14,330	-5,559	-6,881	278	1	2,169	19,302
14,864	-3,953	-6,377	113	-60	4,587	21,348
13,629	-2,631	-5,118	0	-104	5,776	22,912
11,668	-768	-5,298	-173	-182	5,248	24,214
11,116	1,443	-4,784	-256	-200	7,317	25,617
11,491	4,823	-3,673	-272	-201	12,168	28,454
11,261	9,005	-2,835	-244	-225	16,962	31,494
10,365	12,444	-2,055	-247	-215	20,293	33,939

NOTE: n.a. = not available.

These patterns imply that the national value of federal research and development programs (measured by the increasing business income following innovations) is lower now than 10 (or 20) years ago because of the increasing proportion of spending for noncommercial development. Although federal programs now provide half the funding for national research and development efforts, they contribute only one-quarter of net commercial scientific capital. (Net private investment in scientific capital is shown for comparison in Table 7.) This is just under half the share of 10 years ago, underlining the shift in federal support for R&D from a nearly equal partnership with industry in financing industrial innovation to a very subordinate role.

Implications for National Saving and Investment Data

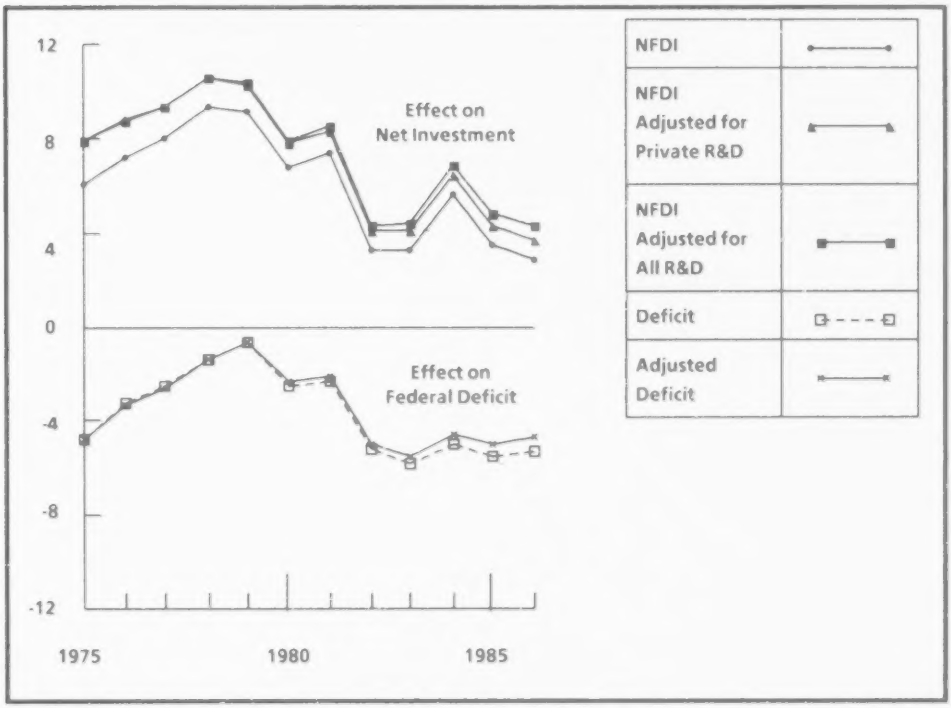
Extending the concept of capital to include scientific capital resulting from R&D would, if carried over to all sectors, increase the measure of national income. At present, business income is measured net of expenditures on R&D. Under expanded capital accounting, business R&D spending would be counted as purchases (from profits) of capital (research) services, and business income would reflect only a deduction for obsolescence of past development efforts. Business saving and income (and hence corresponding national measures) would thus be increased by net private R&D investment.

Adjusting income, saving, and investment data for net investment in R&D raises domestically owned investment rates by up to 0.6 percent of (revised) NNP for federal R&D programs and 1.4 percent overall, when firms' net investment is included. If only the most commercially oriented federal R&D programs are counted as investment, the adjustment is only about 0.3 percent of NNP. The overall adjustment, though larger in 1986 than at any other time in the 1980s, is lower than levels of the mid-1970s, indicating that recent fast growth has not restored research and development to its share of 10 years ago in national income (see Figure 6).

LOANS AND GRANTS TO OTHER SECTORS

A further extension of the definition of federal investment would include federal contributions to investment in other sectors that are, in both accounting and economic terms, income transfers. They occur through loans and grants to individuals and other governments. National income data reflect this: federal financial aid is recorded as federal intergovernmental grants and as corresponding income or revenue that is spent or saved by its recipients along with other income. Thus construction and other fixed purchases financed with this

FIGURE 6. EFFECT OF INVESTMENT IN RESEARCH AND DEVELOPMENT ON NATIONAL SAVING AND INVESTMENT RATES (As a percent of NNP)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis and the National Science Foundation.

NOTE: Adjustments are based on net investment in all R&D categories.

NFDI = Net fixed domestically owned investment.

aid are recorded in the sector that received the aid. Moreover, from an economic point of view, the grants and loans are not greatly different from revenue sharing (which also financed some investment) since, according to the weight of evidence, they do not induce additional investment by recipients but instead substitute for other sources of funds (see Chapter III). In other words, states, local agencies, and individuals receiving federal aid do not appear to invest more of their aid-enlarged income than they would have if the extra income had come from nonfederal or untied sources. Though it is often tied to certain capital programs, federal aid merely allows resources that would otherwise be devoted to those purposes to be diverted to other uses.

The role of federal financial aid in national infrastructure programs has nevertheless been--and remains--substantial. Federal grant programs now amount to nearly half of all physical investment by state and local governments, and nominally cover 80 percent, on average, of the cost of eligible investments. Federal credit subsidies have been important in shaping certain patterns of regional development--for example, through assistance for rural water, electricity, and housing development. This aid ultimately accrues to households through low rates for services. The following sections discuss patterns in federal investment financing for states and localities and households, through grants and credits subsidizing physical investment.

Subsidies for Physical Investment

The argument for counting federal capital grants and credit subsidies for physical investment as part of federal investment activities is that they nominally finance infrastructure and other types of investment that conform with the standard criteria for capital used in the business sector. Including the grants and credit subsidies with investment would thus take account of the federal share in the costs of these investments.

If NIPA principles were extended to government budgets, however, adjustments for investments financed from grants would be included in NIPA data on state and local budgets. This would follow from applying the direct NIPA concepts described in Chapter IV for

federal spending to all government accounts. Thus, in a unified national accounting system, federal budgets would have to reflect both the grant-investment and its immediate transfer to the owning-and-operating state or local government agency so that costs for operating, maintaining, and depreciating the assets could be properly reflected. The data of federal saving and the measure of the federal deficit would remain unchanged. Most credit subsidies for physical investment--largely for housing--are already included in national data. Since information about the quality of investments under grants and subsidized loans is as sparse as that for direct federal investment, measures of investment based on grant outlays or credit subsidies may overstate the value of the investments being undertaken.

Capital Grants to State and Local Governments

Over the last 15 years, federal capital grants to states and local governments have fluctuated around $22 billion a year (in 1982 prices), financing about $11 billion a year in estimated net state and local investment, after deducting straight-line depreciation of assets financed under past grants.2/ Net investment is shown in Table 8, and gross investment from federal grants in Appendix Table B-5.

Compared with overall state and local investment, however, federal grant assistance has been much more stable. The $11 billion a year in net investment from grants (after straight-line depreciation) contrasts with a fall in overall net investment by states and localities from $40 billion in 1970 to about $19 billion of net additions to capital in 1986, with implied negative net investment from sources other than

2. Net investment financed from grants has been estimated using Bureau of Economic Analysis assumptions for service lives of state and local assets, and the depreciation rules for physical assets described in Chapter III. As with federal physical investment, trends for grant-financed capital improvements are similar under both measures of depreciation, and estimates differ only in the levels of net investment accounted. Estimates based on straight-line asset deterioration are used in the main discussion because the assets financed--highways, transit, wastewater, and so on--are subject to wear-and-tear through use.

TABLE 8. NET PHYSICAL INVESTMENT BY STATES AND LOCALITIES FROM GRANTS AND OTHER SOURCES
(NIPA basis, in millions of dollars, at 1982 prices)

	Net Investment from Grants to Cities (Type 1)				
	Urban Development	Transit Systems	Waste-water Treatment	Airports	Subtotal
1949	0	0	3	144	147
1959	316	0	154	189	658
1969	1,857	173	516	184	2,730
1970	3,550	138	661	112	4,461
1971	3,848	255	1,176	124	5,402
1972	4,019	360	1,133	301	5,814
1973	3,835	453	1,347	401	6,036
1974	3,019	660	3,740	409	7,829
1975	3,309	937	3,191	311	7,748
1976	3,917	1,115	5,156	240	9,428
1977	4,331	1,347	4,634	448	10,760
1978	4,056	1,335	4,137	623	10,150
1979	4,468	1,498	4,304	518	10,788
1980	4,848	1,714	4,406	449	11,416
1981	4,324	1,736	3,527	271	9,858
1982	3,495	1,338	2,763	169	7,766
1983	2,939	1,255	1,890	285	6,369
1984	2,909	1,174	1,631	453	6,167
1985	2,788	773	1,796	485	5,842
1986	2,003	515	1,757	525	4,800

SOURCE: Congressional Budget Office, based on data from the Office of Management and Budget and the Bureau of Economic Analysis.

grants between 1981 and 1984.3/ Since the two-year period 1982-1983, however, the trend in overall state and local net investment has been strongly upward, for the first time since the late 1960s. Should

3. This measure uses straight-line depreciation deductions. The Type 2 measure also shows a large decline in state/local net investment, but the surplus over grants, though smaller, remains positive throughout the 1970s and 1980s. See Table 8.

TABLE 8. (Continued)

Net Investment from Other Grants (Type 1)			Net Investment by State and Local Governments			
Highways and Streets	Emergency Public Works	All Other	Federal Grants (Type 1)	Federal Grants (Type 2)	All Sources (Type 1)	All Sources (Type 2)
1,715	-60	20	1,821	2,108	11,116	18,979
9,845	-82	511	10,934	12,051	29,077	41,377
8,146	-123	1,503	12,256	16,099	46,736	64,714
8,519	-125	1,355	14,210	18,353	40,575	60,041
8,440	-125	1,177	14,893	19,408	37,140	57,468
7,122	-125	1,049	13,860	18,735	34,403	55,224
5,319	-124	960	12,190	17,332	30,657	52,586
4,532	-123	1,075	13,313	18,834	31,376	54,159
3,823	-122	798	12,247	18,091	27,038	50,793
5,046	91	764	15,328	21,589	22,071	45,695
4,740	1,620	675	17,795	24,598	15,400	39,728
4,048	3,547	390	18,135	25,395	18,512	42,920
4,002	1,463	320	16,573	24,302	15,499	39,443
4,253	107	181	15,956	24,149	15,146	40,816
3,795	-195	78	13,536	22,198	9,129	33,262
3,141	-242	-102	10,563	19,581	6,239	30,135
4,037	-269	72	10,209	19,517	5,866	30,743
5,352	-267	171	11,423	21,054	9,383	32,596
6,050	-265	216	11,844	21,613	13,831	38,768
6,724	-263	157	11,417	21,514	19,118	43,913

NOTE: Type 1 net investment deducts equal annual amounts for depreciation. Type 2 net investment deducts assets as they are withdrawn from service.

the upward trend continue, any further reduction in grants may simply lower the federal share of public works investment, but not reduce its total.

Significant changes in the composition of federal grant financing are also relevant. Although federal aid for highways has historically been the largest single capital grant program, total federal assistance to cities, through grants for urban development, transit systems, wastewater treatment plants, and airport construction, has histori-

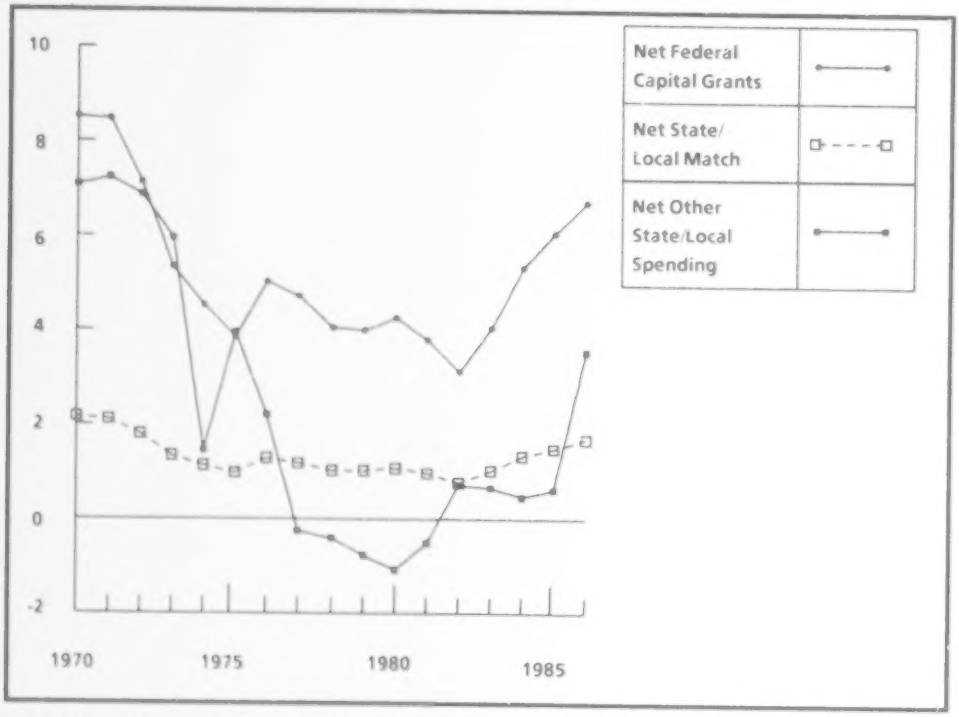
cally been much larger. Throughout much of the 1970s, federal grant aid for highways was $8 billion to $9 billion a year (in 1982 prices) compared with grants for urban areas (except for urban highways) totaling $11 billion to $14 billion annually. These amounts financed net investments of around $4 billion in the highway system, and $7 billion to $10 billion in the cities. Much of the emergency public works assistance of the late 1970s also financed investments in cities. But since the major increase in highway spending authorized by the Surface Transportation Assistance Act of 1982, together with reductions in urban development programs, highway programs have rapidly come to dominate federal capital grant aid to states. By 1985, net highway investment from grants was half of all grant-financed net investment, and in 1986 it was 40 percent more than the level of net additions to cities' assets from grants.

Highways

Until the recent increase in highway grants, the dominant factor affecting state and local highway investment levels was not federal grants but the rapidly declining spending on nonfederal-aid highways--principally on the 500,000 road miles in cities and 2,500,000 road miles in rural areas that are not on the federal-aid system. Between 1969 and 1977, spending on the unaided systems fell from $12 billion to a fairly stable level of $5 billion a year. During the 1970s, investment in local rural roads off the federal-aid system fell by about one-fifth (after accounting for price changes), and that for local urban streets fell by one-eighth, while the states' own investment in state highway networks dropped by over 70 percent. By 1980 the federal grant program (together with state and local matching funds) was contributing half of national highway improvements.

While increases in highway taxes and federal grants for highways have, since 1982, pushed up the national spending total, they have had no apparent effect in improving the condition of the most deteriorated roads, for which spending has risen only marginally. From about 1977 to 1981, spending on unaided highways was barely sufficient to offset estimated depreciation so that net investment in city streets and rural areas was low and may even have been negative (see Figure 7). In 1985, some 36 percent of minor rural roads rated in fed-

FIGURE 7. NET INVESTMENT IN HIGHWAYS BY SOURCE
(In billions of dollars at 1982 prices)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis and the Federal Highway Administration.

NOTE: Net investment in this figure is based on deducting equal annual amounts for depreciation. Net other spending includes net state/local investment on nonfederal-aid projects and other major improvements not classed as investment by the Bureau of Economic Analysis.

eral pavement monitoring were unpaved, and the roads as a group were in only fair condition on average. Most city roads are not included in the pavement rating system, but nearly two-thirds of the urban collector system, which includes some 20,000 miles of city-funded roads, was rated at fair or worse condition. By comparison, 60 percent of the interstate system and half of other major highways were reported in very good or excellent shape.4/

Little is known about the national economic benefits of highway investments. According to previous CBO estimates, for about 40 per-

4. Federal Highway Administration, *Highway Statistics 1985*.

cent of the remaining interstate construction program, benefits to highway users would not support investment. In addition, declining pavement conditions on the most heavily trafficked parts of the federal-aid network--the rural and urban interstate segments--coupled with improved conditions on less traveled systems, showed that the broad national benefits from highway spending could be raised by concentrating on improvements for busier roads or for highways in the worst condition.5/

Similar comparisons for overall nonhighway assistance to cities are not possible because grant aid under block grants--including both urban and community development programs as well as the public works assistance of the 1970s--cannot be allocated to specific purposes. (By default, therefore, all such financing is included in these comparisons as spending from nonfederal sources.) Moreover, experience in the three specific grant programs affecting cities differs.

Airports

Only in airports is overall net investment relatively independent of grant financing. Federal grants for airport construction have financed net improvements varying around $400 million a year since 1975, while overall net investment has been increasing (varying with both expansion needs and borrowing cost, since it is largely debt-financed) along an upward trend of around 8 percent annually during the 1980s. In 1985, net airport investment from all sources stood at just over $1 billion. Should the trend in total spending continue, overall net improvements in airports in 1988 would be in the range of $1.2 billion.

Wastewater

A sharp decline in nonfederal sources of net investment in wastewater treatment began in 1979, followed by a resumption of nonfederal funding in 1984 to levels that are now around the same rate as during the 1970s (see Figure 8). Several factors probably contributed to the rapid decline in net investment from 1979 through 1983.

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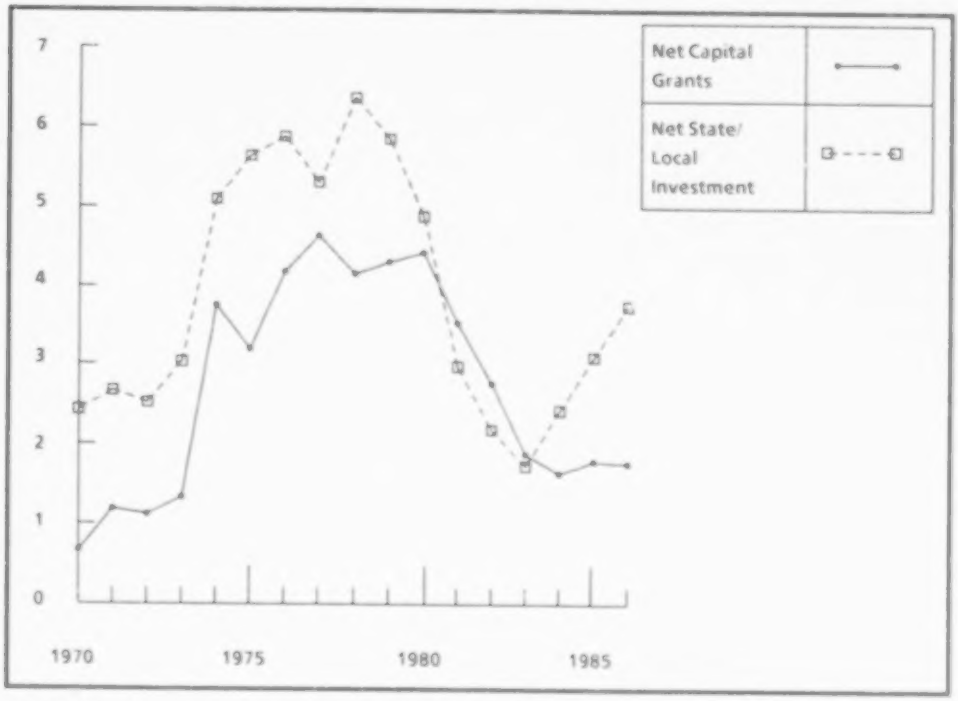
5. Congressional Budget Office, *Federal Policies for Infrastructure Management* (June 1986).

FIGURE 8. INVESTMENT IN WASTEWATER TREATMENT
(In billions of dollars at 1982 prices)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.
NOTE: Net investment is based on deducting equal annual amounts for depreciation.

First, independent studies and those of the Environmental Protection Agency report that the increased federal funding that followed the 1972 Clean Water Act replaced state and local funding rather than raising national investment in wastewater treatment. During the 1970s, state and local government spending fell to little more than that needed to match federal construction grants. Overall state and local government spending from their own resources fell by 80 percent between 1972 and 1976, while federal spending quintupled to 90 percent of national construction outlays. By 1982, independent construction was less than $1 billion (at 1982 prices) compared with $2.3 billion in 1970.6/

6. See James Jondrow and Robert A. Levy, "The Displacement of Local Spending for Pollution Control by Federal Construction Grants," *American Economic Review*, vol. 74, no. 2 (May 1984), and Environmental Protection Agency, *Study of The Future Federal Role in Municipal Wastewater Treatment*, Report to the Administrator (December 1984).

Second, the 1978 Clean Water Act extended the 1983 national target for clean water to 1988. This, together with rising interest rates for municipal borrowing beginning in 1980, may have eased pressure to maintain a high rate of investment, and probably induced some localities to defer investment plans. Third, during the same period, management of the clean water assistance programs was gradually transferred from the Environmental Protection Agency to the states, and 40 states have accepted full delegation since 1977. Under state management, priority lists for construction were revised, which may have delayed new starts.

Finally, the 1978 act provided incentives for using innovative technologies so that project sponsors were encouraged to use less costly treatment systems if those systems would meet clean water standards. Use of innovative treatment methods may have permanently lowered (by an unknown amount) the investment cost needed to achieve overall clean water standards. Any such lowering, however, would contribute to a long-term decline in the costs of meeting clean water goals, rather than to a sudden falloff in spending.

The resumption in nonfederal net investment evident from 1983 has driven the federal share in national investment below the 55 percent match for federally aided projects under current law: the 1986 federal grant share of net additions to wastewater treatment plants was 47 percent. The relationship of these two percentages implies about the same share of non-aided construction as during the 1970s, when the grant program offered 75 percent of construction costs and the federal share was 64 percent.

Transit

Analysis of the third grant program contributing to cities' infrastructure--transit aid--suggests that cities have been unable to use all the aid provided to them. Net investment and net grant assistance for transit systems have risen fairly steadily (apart from a sharp drop in 1978, probably reflecting New York's financial crisis) and at much the same pace between 1970 and 1981. Since then, however, the paths have diverged: overall net investment has continued to rise to just under $3 billion a year in 1985, while net grant aid for investment has fallen to around $700 million a year. But the falloff in net investment

from grants results not from reduced program support but from a much reduced spending of appropriated resources.

Since 1982, unobligated balances--the differences between amounts appropriated by the Congress and those obligated for spending by recipients--have been growing sharply. By 1985 transit agencies nationwide had $1.8 billion (in 1982 prices) available that they had not committed to projects--well above the amount that would reflect the ordinary delay between authorization of spending and letting of contracts for supply or construction. About $1 billion of the unobligated funds were resources under the formula program that allocates aid to all cities according to population and density criteria. The remainder was largely in the discretionary program that finances named projects in different cities, particularly for rail modernization and new transit systems. The balance in the account for funding for the Washington area Metro system was $200 million, because of construction delays.

According to a study by the General Accounting Office, $707 million of the $994 million in unobligated balances at the end of 1985 under the Urban Mass Transportation Administration's formula grant program (which the 1982 Surface Transportation Assistance Act effectively converted from operating to capital aid) has been allocated to cities of one million inhabitants or less that have not applied for assistance.7/ For many of these cities, modernization of their bus service was completed under the earlier program. The gap in spending of discretionary resources arises from the Administration's "no new starts" policy that has delayed new construction on new (mostly rail) transit systems in seven cities. From 1982 to 1985, states' and localities' overall investment in transit systems from their own resources rose rapidly, particularly in older northeastern cities where transit systems can borrow and also receive state aid. The sharp rise for these cities indicates strong demand for capital in areas other than those to which appropriations had been allocated, or for project types other than those eligible for aid.

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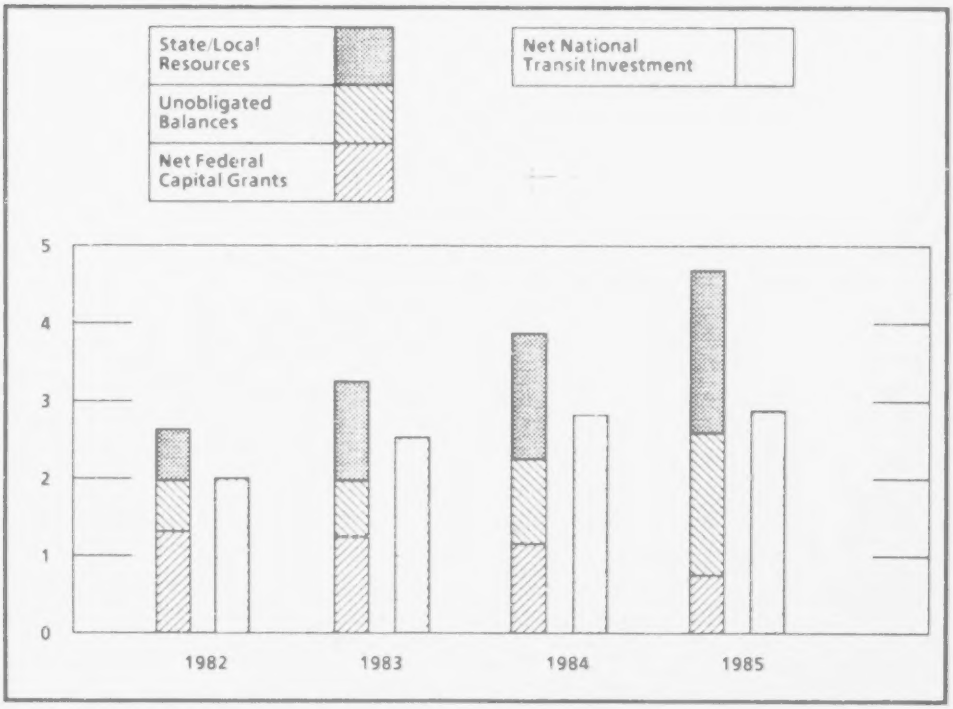
7. General Accounting Office, "Budget Issues, Analysis of Unexpected Balances at Selected Civil Agencies," GAO/AFMD-86-76BR (September 1986). GAO data are at current price levels.

Had earmarking of both eligible recipients and eligible projects been avoided so that appropriations could have been applied to other ongoing capital improvements, the unobligated balances could have been used up. Doing so would have maintained the high ratio of federal grants in overall net additions to transit capital. On the other hand, since increasingly large amounts of nonfederal financing have been available for these other projects since 1981, the expansion of federal capital grants for transit in 1982 seems simply to have provided inflexible and excessive aid (see Figure 9).

FIGURE 9. RESOURCES AVAILABLE FOR TRANSIT INVESTMENT
(In billions of dollars at 1982 prices)



SOURCE: Congressional Budget Office, from budget data.

NOTE: Net investment is based on equal annual deductions for depreciation.

Credit Subsidies for Physical Investment

Credit subsidies for physical investment have fallen from around $15 billion a year (at 1982 prices) in the late 1970s to $6 billion or less annually during much of the 1980s. Estimates for 1987 show subsidies at around $4.5 billion. Reductions in this form of federal support for investment have occurred in both subsidized direct lending and in federal loan guarantees. Subsidized lending for physical capital is now less than 40 percent of all federal credit subsidies.

Current credit subsidies for physical capital favor small business development and rural electrification projects; the guarantees are mostly for housing investment. Direct loan subsidies in the late 1970s also provided substantial support for rural and low-cost housing, while support for housing investment through federal guarantees was much higher than now. Subsidy reductions have been achieved both by reducing authorization for lending (sometimes partly offset by other forms of subsidy, such as housing vouchers), and by stiffening loan terms or increasing guarantee fees--thus reducing not only the subsidy rates on loans but also the demand for subsidized lending.

Implications for National Saving and Investment Data

Including federal subsidies for fixed capital investment in national saving and investment data raises the same issue as including direct federal investment: budget accounts can be fairly simply split into capital and current spending, but it is questionable whether the net public investment is a clear addition to national investment, is partly included in private totals, or is overstated because of low financial returns. A second issue is that although much state and local investment is financed from the federal budget, that part financed from grants would conventionally be treated as a subset of state and local, rather than federal, investment. Similarly, the increased public saving that resulted would be measured as part of state and local government saving, rather than as a reduction of the federal deficit. No adjustment would be made for credit subsidies for physical investment, since they are already properly included in private saving and investment data.

Basing the adjustments on the most generous measure of net investment from federal grants (deducting depreciation only when assets are withdrawn from service) would raise public saving (by increasing the combined surplus of state and local governments) by 0.7 percent of net national product. This percentage is nearly half of the overall 1.3 percentage points added to the national saving rate by recognizing state and local government physical investments. Using straight-line depreciation would add only 0.3 points to the saving rate from grants, with an overall addition from all state and local net investment of 0.6 percent of NNP. In this second measure, additions from grants exceeded overall additions for much of the past 10 years because of the negative local own-source investment discussed earlier. Patterns in investment and saving rates under these assumptions are shown in Figure 10.

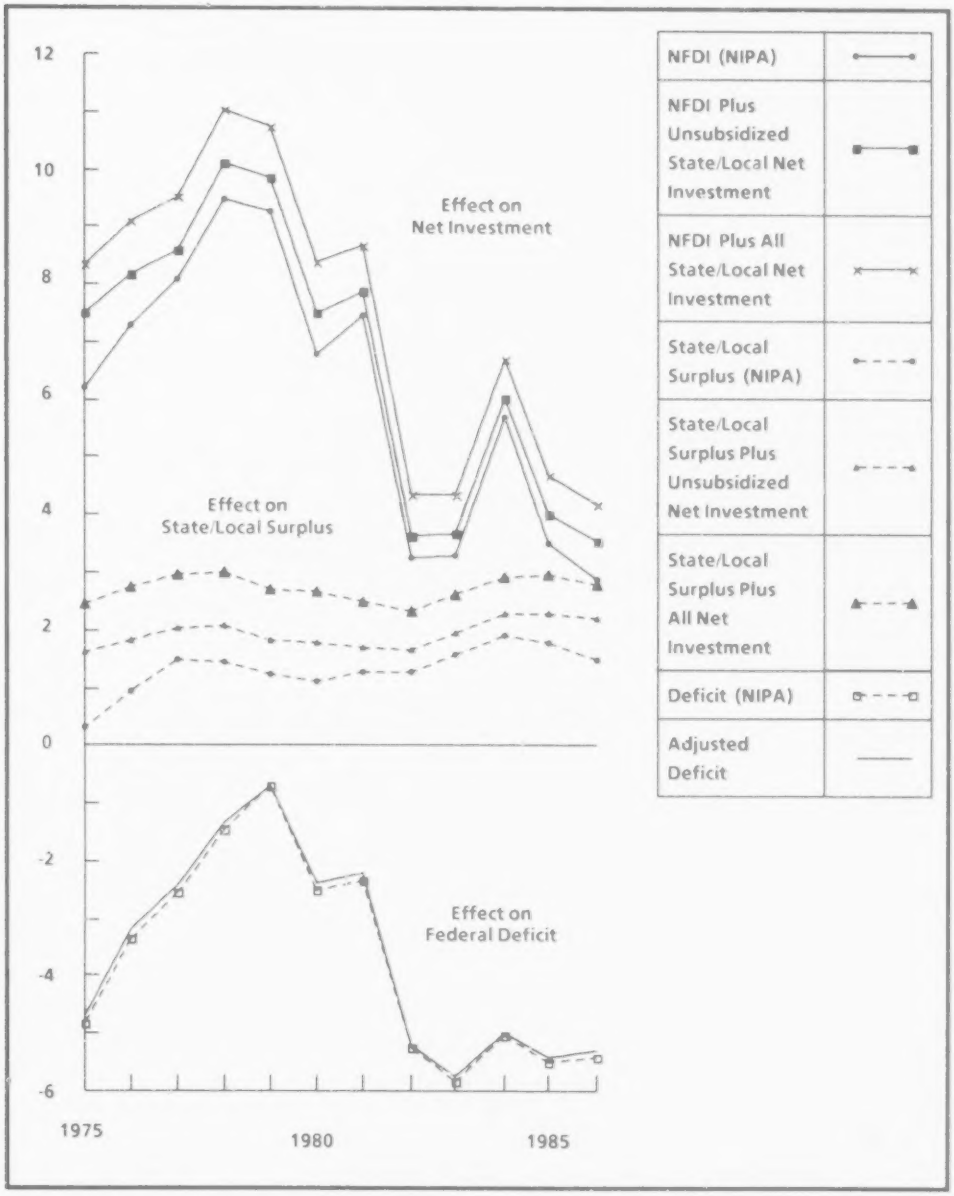
SUBSIDIES FOR INVESTMENT IN HUMAN CAPITAL

Including investment in human capital in national totals would acknowledge the contribution made by the skills and other developed qualities of the work force. Current accounting treats these skills and qualities as freely provided, and may thus obscure the importance of human development vis-a-vis physical investment.

Although the concept of human capital is clear, it is difficult to say where investment in it ends. Researchers have identified training, knowledge, and skill as important components of human capital.8/ Spending for education has received substantial attention in studies of growth and productivity. Theoretical cases can be made for including expenditures on health and mobility in such investment, and at least

8. The concept of human capital as a complement to physical capital in production has been in occasional use since the mid-1930s, but development of the concept and a measurement system for it is generally attributed to the work of Schultz and Becker in the early 1960s. See Theodore W. Schultz, "Investment in Human Capital," *American Economic Review*, vol. 51 (March 1961), and Gary Becker, "Investment in Human Capital: A Theoretical Analysis," *Journal of Political Economy*, vol. 70 (Supplement: October 1962).

FIGURE 10. EFFECT OF FEDERAL, STATE, AND LOCAL PHYSICAL INVESTMENT ON NATIONAL SAVING AND INVESTMENT RATES (As a percent of NNP)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis.

NOTE: Net investment is based on deducting discards from capital stocks from gross investment. NFDI = Net fixed domestically owned investment.

one major study has widened the field even farther.9/ But if the scope of investment activity in human capital is widened to include activities that provide non-income benefits to future generations (similar to investment in defense assets, for example), then practically all spending on social welfare functions could be counted as investment.

Equally important is the lack of a clear standard in this area for defining annual capital consumption, with the attendant difficulties of distinguishing between investment and consumption elements in human development. Unemployment insurance, for example, has been classed with investment activity in at least one study, because it improves employers' abilities to hire and fire (and thus raises profits) by providing a cushion for workers moving from job to job. Logically, however, it should be counted as current consumption rather than investment spending. The asset would be the pool of unemployed workers just necessary to maintain (some desirable level of) work force mobility; the investment would be the spending on training for eventually unemployed workers, and the capital consumption would be the unemployment compensation payable to the pool.

More broadly, health care invokes the same concept of human capital as does education. A healthy, well-trained work force could be regarded as a national asset created by expenditures on health care and education. But despite this theoretical argument, it is difficult to fit health care into the human capital framework. Society provides health care on bases other than productivity, while education beyond a basic level is often available only competitively. Moreover, federal health programs have a large constituency among the elderly, who now receive about one-quarter of the benefits. Taken altogether, education probably has a larger investment component (that is, spending directed at increasing income) than health. Also, earnings and attainments--the primary indicators of human capital--are much more easily distinguished by occupation or skill levels than by health

9. Concepts of human capital dating from the 1930s argue that workers' skills cannot reasonably be separated from the workers themselves, and that all activity leading to long-term changes in people should be called investment. Under this argument, child-rearing and nutrition programs would be included with human capital formation. See Irving Fisher, *The Nature of Capital and Income* (New York: Macmillan, 1930). This concept is applied in John W. Kendrick, *The Formation and Stocks of Total Capital* (New York: National Bureau of Economic Research, 1976).

ratings. Finally, health expenditures may be inversely related to healthiness; more often than in education, perhaps, large expenditures for medical care may produce only small changes in health status. Thus it is difficult to find a satisfactory basis for measuring investment in human capital through medical care.

Measuring Investment in Human Capital

For reasons spelled out in Chapter III, no data series is presented on federal investment in human capital. Rather, because of the speculative nature of such data--what should be included and excluded, how noninvestment components of spending for human development should be treated, and how capital consumption may be estimated--only broad indicators of federal assistance in relevant fields can be presented. Moreover, since federal programs in human capital areas, like grants to states and localities, mostly provide subsidies that finance investment by others, the broad thrust of the discussion examines how national trends in saving and investment would change if the concept of human capital development were included in official data on saving and investment.

According to NIPA data, federal spending for education and training services (that is, other than capital construction, research and development, or capital grants for these functions) rose from around $23 billion in 1975 to a peak of around $25 billion in 1980 and has since fallen again to $17 billion (in 1982 dollars). To this spending may be added estimates for the value of loan subsidies for education under federal programs. This study estimates that these subsidies have increased from around $750 million in the late 1970s to around $2.9 billion in 1986. Altogether, these data put resources for education services under federal programs at around $20 billion now. In contrast, comparable national spending, including costs of public education to states and localities and amounts spent for private schools by families, has risen fairly steadily from just over $170 billion to around $190 billion (NIPA basis, also in 1982 dollars). None of these measures makes allowance for the share of the expenditures that could be considered consumption rather than investment, or for the share going to capital consumption, and thus they only roughly correspond with, but probably overstate, investment in human capital as measured in other studies. Unlike other investment extensions discussed previously, the

federal share in these investmentlike activities is relatively small (less than one-eighth) and declining.

Most of the fall in the federal share has been borne by cuts in student assistance and in training assistance (which the national accounts identify as transfer payments to individuals for education, and training grants-in-aid to states and localities, respectively). Together spending on these programs has fallen by 40 percent (after price adjustments) since 1980. This decline, together with the increase in subsidized lending for higher education, has tended to switch assistance to students at colleges and universities from grants to loans. Whereas loan subsidies were 22 percent of federal student assistance in 1980, their share was up to 38 percent in 1986.10/ Education grants-in-aid to states and localities (other than for capital projects) also fell by about one-third (after price adjustments) between 1980 and 1983, but has since recovered to around $7 billion (in 1982 prices) or about three-quarters of the 1980 level. Grants-in-aid for training are much lower than in earlier years and are now around $2.9 billion (in 1982 prices). Overall, the effect of these changes has been to lower the share of grants-in-aid in overall federal assistance from about 58 percent in 1980 to 45 percent.

Direct federal spending for education and training is minor and mostly consists of providing education or training for federal employees. Were these expenses to be capitalized, net investment for this purpose might now be negative. Although spending for federal agency in-house training has approximately doubled since 1970, and now runs at around $1 billion a year, adjusting it for the turnover of trained employees indicates that it may not be sufficient to offset increases in labor costs and the estimated loss of skills through retirement or other turnover. To the extent that federal employees use skills learned in federal training programs in other jobs after retirement, however, national investment may remain positive.

The relatively smaller role of grants-in-aid in education tends to shift the balance of federal assistance away from the basic skills that

10. Federal student assistance is taken from NIPA data for federal payments to individuals ($4.8 billion, including veterans' education benefits in 1986), plus $2.9 billion in loan subsidies. Both figures are in 1982 prices as measured by the implicit price deflator for education expenditures.

grants-in-aid finance. This shift may have lowered the national value of federal education assistance. No direct measures of the value of investment through federal education programs exist, but worldwide studies of education concur that its income-enhancing results are highest for basic or primary schooling, and follow a diminishing trend for secondary and higher levels.11/ Federal education grants-in-aid to the states and localities are primarily targeted to basic skills--migrant English, literacy among disadvantaged students, and so on--that would, according to this view, provide the highest returns.

Effect on Saving and Investment Rates

The NIPA measures of education and training spending are sizable and would, if included as national investments, significantly alter measures of national investment. Federal spending of around $20 billion represents, like other extended investment concepts, only a small share--about 0.7 percent--of net national product. Overall national spending, however, is around 6 percent of NNP, and if included would raise the national investment rate to about 9 percent, through additions to household investment.

Including expenditures on education and training as human capital investment would, however, add great uncertainties to national data on capital formation. First, the estimates above use spending data unadjusted either for noninvestment aspects of

11. Returns to education investment are usually measured from the point of view of students, by comparing costs of education (including, where relevant, costs of income delayed by schooling) and additional earnings of graduates (over those of workers with lower qualifications) at each level. But the lack of an identifiable control group of illiterate adults in the developed countries prevents one from directly estimating the benefits of education in basic skills in those countries. Moreover, some researchers question whether education attainments adequately reflect levels of skill that influence earnings, and others argue that results based on individual returns are less informative than analyses of aggregate changes in education or skill levels. Private rate-of-return measures reflect only costs and benefits to students. Corresponding estimates of social returns correct for subsidies that reduce private education expenditures. All estimates are usually corrected for the effects of experience gained after graduation. The estimates therefore reflect average returns to students completing different levels of school. They can be taken as approximations for marginal returns to education programs to the extent that they show what an additional student could expect to earn from educational investment (or what a student could expect to earn from additional education).

education and training activities or for capital consumption. In official data, and in all the other investment categories discussed in this paper, net investment after such adjustments is the usual measure. But in the area of human capital, such adjustments must be wholly speculative. Second, limiting human capital investment to education and training is itself arbitrary. As discussed earlier, many researchers have used a much broader coverage of income-enhancing human capital activities, and some have even argued that measures of human capital should extend beyond income-earning qualities to general measures of human development. Thus, unlike the "long-lived income-earning plant and equipment" concept of physical capital, the idea of human capital has no generally accepted bounds.

OVERALL EFFECTS OF EXTENDING CAPITAL CONCEPTS ON NATIONAL SAVING AND INVESTMENT RATES

In Chapter IV it was shown that adding federal physical investment to the official national investment data would increase net domestic fixed investment by $4 billion a year or less, and would raise national capital formation by as little as 0.1 percent of net national product. The size of the increment fluctuates somewhat, but has remained at around this level for the last decade. Thus, recalculating national saving and investment data to include federal physical investment that is similar to the investment of households or firms would not significantly change the trend or level of the official data, nor the conclusion that capital formation rates have fallen steeply during the 1980s.

The extensions discussed in this chapter extrapolate the implied NIPA characterization of investment to other investmentlike activities, and would, if adopted, also change some measures of private investment. In the federal sector, the adjustments would all generally be larger than that implied by the NIPA-based physical capital adjustment, but would still be less than 1 percent of net national product (typically, 0.6 percent to 0.7 percent). Despite fairly large increases in purchases of weapons systems (raising net investment in defense assets) and in military research and development programs (raising net investment in intellectual capital), none of the extended concepts would make a large change in official data, and together

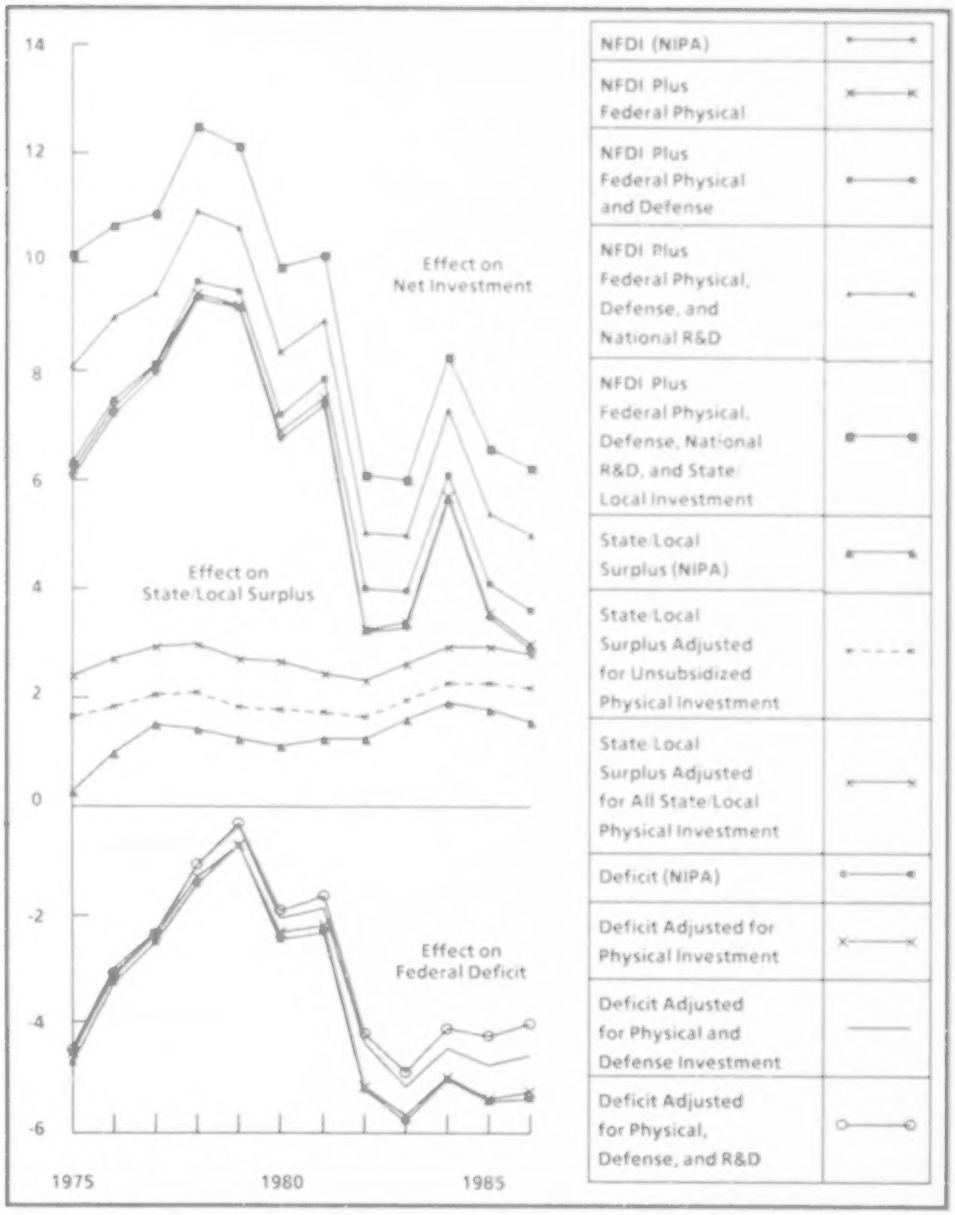
these concepts do not suffice to offset the fall in national investment during the 1980s. Figure 11 illustrates these overall effects.

Overall, using the more generous measure of net public investment in each category, the adjustments in Figure 11 would have added just under two percentage points to net domestically owned fixed investment as a percent of NNP in the late 1970s and just over two percentage points in the mid-1980s. Thus, the rate of public investment has changed very little, and not sufficiently to offset falling private investment rates. The increase in public saving associated with the extended concepts would be split between federal (about 1.2 percent of NNP) and state and local governments (about 1.3 percent of NNP), amounting altogether to just over three-quarters of the increased net investment. After adjusting for net investment in physical civilian and defense assets and in research and development, federal deficits would remain at around 4 percent of net national product, and state and local surpluses (because of the physical investment they undertake) would increase to about 3 percent of NNP.

The adjustments would also raise measures of private saving by about 0.7 percent of NNP, because of spending on privately financed research and development that would, under the new concepts, be treated as investment. Much larger increases in private saving could probably be recorded if it were feasible to account accurately and consistently for net investment in human capital. Expenditures on national education and training, for example, at around $200 billion, are nearly 6 percent of NNP, and around one-third of gross private saving. Thus, even with sizable adjustments for noninvestment elements in these activities and for capital consumption, the effects of including some measures of human capital formation in national saving and investment data might remain large.

In all cases, however, the extension of capital concepts to government budgets would add considerable uncertainty to official data on national saving and investment. Measures of net federal investment in physical assets similar to those for business and household investment may, under alternative assumptions about the appropriate treatment of depreciation, vary by up to one-third of annual spending. Moreover, information on the quality of the in-

FIGURE 11. OVERALL EFFECTS OF DIFFERENT CAPITAL CONCEPTS ON NATIONAL NET INVESTMENT AND PUBLIC SAVING (NIPA basis, as a percent of NNP)



SOURCE: Congressional Budget Office, based on data from the Bureau of Economic Analysis and the National Science Foundation.

NOTE: Net investment is based on the larger measure derived in each category. NFDI = Net fixed domestically owned investment.

investments and their contributions to increasing national income is patchy; and it is not clear to what extent federal investments are designed to achieve broader social goals not reflected in national income data. In all of the other concepts, while the claim that spending adds to future output (and therefore should be considered as investment) can be fairly easily understood in principle, no way of measuring the effects is available. Defense assets may produce deterrence benefits, but these benefits are not measured in national income statistics; research and development assists industrial and commercial innovation, but there is no consensus about the links between spending, R&D activity, and future payoffs; and federal subsidies for capital purposes in the form of credits and grants have been found to add little to national investment totals. Moreover, determining which types of activity to include in these concepts, and whether and how to represent capital consumption, involves speculation or at best informed judgment, since there are no clear or verifiable measured links between investment and income.

APPENDIXES

APPENDIX A

ASSUMPTIONS ABOUT SERVICE LIVES AND RETIREMENT PATTERNS FOR GOVERNMENT PHYSICAL CAPITAL

Estimates for depreciation and retirement of government assets used to derive figures on net physical government investment in Chapter IV and Chapter V are based on assumptions about asset service lives and retirement patterns shown in this appendix. Table A-1 shows the assumptions about average service lives for government-owned equipment and structures. Average service lives for equipment are assumed to range between 10 years and 30 years, depending on the type of equipment. Government structures are assumed to remain in use for an average of between 32 years and 80 years, with the majority averaging 50 years or 60 years in service.

Table A-2 shows estimated retirement patterns for government assets. Retirement patterns, which describe the variations in the average service lives, are modified from retirement patterns for industrial property. According to these variations, some nonresidential assets are assumed to be retired from use in something under half the average service life, while others remain in use for more than 50 percent longer than the average life. Retirement of residential assets begins almost as soon as some assets are put in service, but others remain in use until almost twice the average service life.

TABLE A-1. BUREAU OF ECONOMIC ANALYSIS ASSUMPTIONS ABOUT SERVICE LIVES FOR GOVERNMENT-OWNED PHYSICAL CAPITAL

	Life (Years)
Nonresidential Equipment	
Federal	
Military a/	
Aircraft	12
Missiles	10
Ships	30
Electronic equipment	14
Vehicles	20
Other equipment, including weapons	10
Nonmilitary	
Government-owned, privately operated a/	
Department of Energy	25
Department of Defense	19
Maritime Administration	30
National Aeronautics and Space Administration	15
Enterprises a/	
Power-related b/	25
Other c/	15
Other	
Industrial plant equipment a/	19
All other	15
State and local (including enterprises)	15
Nonresidential Structures	
Federal	
Military d/	50
Nonmilitary	
Government-owned, privately operated a/	32
Enterprises a/	
U.S. Postal Service, Commodity Credit Corporation	50
All other	60

(Continued)

TABLE A-1. (Continued)

	Life (Years)
Nonresidential Structures (Continued)	
Federal (Continued)	
Other	
Buildings	
Industrial	32
All other	50
Highways and streets	60
Conservation and development	60
Other	50
State and local	
Buildings	50
Highways and streets	60
Conservation and development	60
Sewer systems	60
Water supply facilities	60
Other	50
Residential Equipment and Structures	
One-to-four-unit structures	80
Five-or-more-unit structures	65

SOURCE: Department of Commerce, Bureau of Economic Analysis, *Fixed Reproducible Tangible Wealth in the United States, 1925-1985* (June 1987).

a. Service lives for these categories are varied over time. The lives shown are those used for investment that had not been discarded prior to 1986.

b. Consists of Bonneville Power Administration, Colorado River Basin Project, Southwestern Power Administration, Tennessee Valley Authority, and Upper Colorado River Storage Project.

c. Consists of Alaska Railroad, Commodity Credit Corporation, St. Lawrence Seaway Development Corporation, and U.S. Postal Service.

d. Includes troop housing; family housing for the Armed Forces is included in federal residential capital.

TABLE A-2. BUREAU OF ECONOMIC ANALYSIS ASSUMPTIONS ABOUT RETIREMENT PATTERNS

Nonresidential Assets		Residential Assets	
Percent of Average Service Life	Cumulative Percent of Original Expenditures Discarded	Percent of Average Service Life	Cumulative Percent of Original Expenditures Discarded
Less than 45	0	Less than 5	0
45	1.2	5	0.1
50	2.4	10	0.3
55	4.1	15	0.5
60	6.5	20	0.7
65	9.7	25	1.0
70	13.7	30	1.3
75	18.7	35	1.7
80	24.6	40	2.1
85	31.2	45	2.7
90	38.4	50	3.5
95	46.1	55	5.0
100	53.9	60	7.2
105	61.6	65	10.2
110	68.8	70	14.1
115	75.4	75	19.0
120	81.3	80	24.8
125	86.3	85	31.3
130	90.3	90	38.4
135	93.5	95	46.1
140	95.9	100	53.9

(Continued)

TABLE A-2. (Continued)

Nonresidential Assets		Residential Assets	
Percent of Average Service Life	Cumulative Percent of Original Expenditures Discarded	Percent of Average Service Life	Cumulative Percent of Original Expenditures Discarded
145	97.6	105	61.6
150	98.8	110	68.7
155	100.0	115	75.2
		120	81.0
More than 155	100.0	125	85.9
		130	89.8
		135	92.8
		140	95.0
		145	96.5
		150	97.3
		155	97.9
		160	98.3
		165	98.7
		170	99.0
		175	99.3
		180	99.5
		185	99.7
		190	99.9
		195	100.0
		More than 195	100.0

SOURCE: Department of Commerce, Bureau of Economic Analysis, *Fixed Reproducible Tangible Wealth in the United States, 1925-1985* (June 1987).

NOTE: BEA modifications of Robley Winfrey, *Statistical Analysis of Industrial Property Retirement*, Bulletin 125 (Ames, Iowa: Iowa Engineering Experiment Station, Iowa State College, December 1935).

APPENDIX B

ESTIMATES OF GROSS INVESTMENT (IN 1982 PRICES)

Chapter IV and Chapter V show estimates of net investment for four different concepts of government investment. Tables B-1 through B-5 show corresponding estimates of gross investment for each of these concepts. Table B-1 shows gross investment estimates corresponding with the estimates in Chapter IV of net federal physical investment that is comparable with NIPA estimates of net private investment.

The other appendix tables show gross investment for the extended concepts of capital discussed in Chapter V. Table B-2 shows gross federal investment in defense assets, and Table B-3 shows gross private spending for research and development corresponding with gross private investment in intellectual capital. Gross federal investment in research and development is shown in Table B-4. Lastly, Table B-5 shows gross federal capital grants to state and local governments for infrastructure and other physical capital.

TABLE B-1. GROSS FEDERAL PHYSICAL INVESTMENT
(NIPA basis, in millions of dollars, at 1982 prices)

	Structures					
	Civilian Nonresidential					
	Buildings			Other Civilian Nonresidential		
Year	Industrial	Hospital and Education	Other	Highways	Conservation and Development	Other
1949	575	633	547	252	3,572	127
1959	462	173	838	362	3,605	170
1969	229	254	537	619	3,490	88
1970	169	340	445	671	3,766	135
1971	381	390	523	709	4,196	180
1972	0	264	617	705	4,175	394
1973	333	296	805	584	4,354	531
1974	204	287	629	427	4,443	401
1975	0	316	725	469	4,456	400
1976	0	335	422	531	4,528	433
1977	0	404	1,460	606	4,637	408
1978	0	452	885	550	5,460	409
1979	0	435	814	568	5,013	279
1980	0	472	775	420	4,948	271
1981	0	522	786	708	4,670	183
1982	0	431	520	654	4,119	204
1983	1	396	708	477	3,955	203
1984	1	450	930	503	3,725	206
1985	1	460	1,086	410	3,600	26
1986	1	490	1,133	346	3,498	368

SOURCE: Department of Commerce, Bureau of Economic Analysis, Reproducible Wealth Series.

NOTE: Excludes government assets operated by private firms and the transfer of the Alaska Railway to the State of Alaska in 1985.

TABLE B-1. (Continued)

Structures (Continued)		Equipment		
Residential Investment	Military Structures	Industrial	Other	Gross Federal Investment
-568	662	1,258	564	7,623
1,885	5,540	1,451	996	15,483
338	2,558	2,267	1,812	12,192
442	1,915	2,322	1,215	11,420
1,076	2,291	2,556	716	13,019
2,008	2,346	699	2,216	13,424
1,824	2,400	1,093	936	13,155
1,529	2,124	1,017	1,130	12,191
396	2,702	733	735	10,933
251	2,397	757	812	10,467
520	2,287	1,213	802	12,337
860	2,221	1,506	841	13,185
410	1,971	1,644	1,121	12,255
749	2,292	1,526	1,796	13,249
690	1,955	1,435	1,424	12,374
598	2,343	2,500	383	11,752
1,047	2,800	2,490	495	12,570
1,344	2,908	1,473	947	12,487
1,470	3,204	1,528	1,106	12,024
2,044	3,427	932	1,204	13,442

TABLE B-2. GROSS INVESTMENT IN DEFENSE ASSETS
(NIPA basis, in millions of dollars, at 1982 prices)

Year	Military Weapons and Vehicles	Missile Silos	Total Defense Assets
1949	9,211	0	9,211
1950	9,087	0	9,087
1951	21,014	44	21,058
1952	43,786	307	44,093
1953	42,288	557	42,845
1954	35,239	597	35,836
1955	27,862	423	28,285
1956	26,048	293	26,341
1957	20,251	281	20,532
1958	20,642	0	20,642
1959	21,904	183	22,087
1960	22,432	117	22,549
1961	25,724	119	25,843
1962	25,616	86	25,702
1963	25,862	57	25,919
1964	23,718	45	23,763
1965	21,270	53	21,323
1966	22,951	86	23,037
1967	20,827	113	20,940
1968	21,236	90	21,326
1969	20,788	52	20,840
1970	20,680	25	20,705
1971	19,566	19	19,585
1972	24,340	104	24,444
1973	21,062	131	21,193
1974	19,325	145	19,470
1975	23,529	140	23,669
1976	25,432	135	25,567
1977	23,745	88	23,833
1978	29,770	7	29,777
1979	32,725	0	32,725
1980	32,803	0	32,803
1981	34,580	0	34,580

SOURCE: Congressional Budget Office, from budget data and Bureau of Economic Analysis.

TABLE B-3. PRIVATE GROSS INVESTMENT IN INTELLECTUAL CAPITAL THROUGH RESEARCH AND DEVELOPMENT
(In millions of dollars, at 1982 prices)

	Research	Development	Total
1960	5,871	9,615	15,485
1969	8,872	18,103	26,975
1975	9,093	19,750	28,843
1976	9,593	20,683	30,276
1977	9,914	21,571	31,484
1978	10,474	23,118	33,591
1979	11,088	24,686	35,774
1980	11,635	27,037	38,672
1981	13,162	27,727	40,808
1982	13,686	29,137	42,823
1983	14,310	30,455	44,765
1984	15,606	32,611	48,217
1985	16,713	35,202	51,915
1986	17,675	37,593	55,209

SOURCE: Congressional Budget Office, based on budget data from the National Science Foundation and the Office of Management and Budget.

TABLE B-4. FEDERAL GROSS INVESTMENT IN INTELLECTUAL CAPITAL THROUGH RESEARCH AND DEVELOPMENT (NIPA basis, in millions of dollars, at 1982 prices)

	Federal Science, Industry, and Commerce Applications							
	Federal R&D			Federal Research				Total Federal Industrial/ Commercial R&D
	Energy	General Science	Agriculture, Transport, and Other	Military	Space	Health	Environment and Natural Resources	
1960	1,637	285	1,429	4,374	1,222	1,354	344	10,645
1969	2,604	877	3,045	4,597	2,275	2,769	642	16,808
1975	2,534	1,035	2,855	2,888	1,352	2,886	864	14,413
1976	3,349	1,099	2,520	2,722	1,783	3,025	807	15,305
1977	3,884	1,029	2,715	2,731	1,824	2,446	751	15,380
1978	4,306	1,028	2,913	2,808	1,744	3,486	819	17,104
1979	4,795	1,049	2,749	2,764	1,788	3,800	1,007	17,952
1980	4,489	1,016	2,688	2,988	2,386	3,958	964	18,488
1981	4,380	1,001	2,500	3,054	1,582	3,962	832	17,311
1982	3 596	1,015	2,192	2,923	935	3,992	777	15,430
1983	3,078	988	2,082	3,079	1,104	3,960	765	15,057
1984	3,373	1,057	2,244	2,973	1,296	4,021	733	15,698
1985	3,776	1,114	2,329	2,766	742	4,338	716	15,781
1986	2,760	1,234	2,313	2,843	745	4,533	727	15,156

SOURCE: Congressional Budget Office, based on data from the National Science Foundation and the Office of Management and Budget.

TABLE B-4. (Continued)

Federal Development			Other Federal		
Military	Space	Health	Environment and Natural Resources	Total Other Federal	All Federal R&D
24,276	970	10	47	25,303	35,948
20,303	9,292	522	175	30,292	47,100
15,166	3,937	737	257	20,096	34,509
14,426	3,668	629	231	18,954	34,259
14,648	3,493	488	174	18,804	34,183
14,894	3,262	633	224	19,013	36,116
14,360	3,261	644	198	18,464	36,416
15,368	2,848	545	157	18,916	37,405
16,220	3,017	503	130	19,871	37,181
17,508	1,588	379	66	19,540	34,970
18,878	1,058	340	53	20,319	35,386
21,561	1,363	337	60	20,322	39,020
25,148	1,598	377	39	27,163	42,943
28,276	1,976	383	43	30,678	45,833

TABLE B-5. PHYSICAL INVESTMENT FINANCING THROUGH GRANTS TO STATES AND LOCAL GOVERNMENTS
(NIPA basis, in millions of dollars, at 1982 prices)

	Investment from Grants to Cities				
	Urban Development	Transit Systems	Wastewater Treatment	Airports	Subtotal
1949	0	0	3	149	152
1959	338	0	160	218	716
1969	2,127	222	574	261	3,184
1970	3,898	200	732	192	5,022
1971	4,281	340	1,267	208	6,096
1972	4,543	477	1,246	394	6,659
1973	4,448	610	1,484	503	7,045
1974	3,707	875	3,943	522	9,045
1975	4,078	1,232	3,451	432	9,193
1976	4,782	1,509	4,491	368	11,150
1977	5,302	1,861	5,054	588	12,804
1978	5,129	1,976	4,633	778	12,517
1979	5,654	2,285	4,882	687	13,508
1980	6,157	2,670	5,068	630	14,525
1981	5,748	2,871	4,260	462	13,340
1982	5,019	2,631	3,556	367	11,572
1983	4,554	2,706	2,729	492	10,480
1984	4,616	2,782	2,511	673	10,581
1985	4,586	2,511	2,721	719	10,537
1986	3,878	2,364	2,728	774	9,744

SOURCE: Congressional Budget Office, based on data from the Office of Management and Budget and Bureau of Economic Analysis.

TABLE B-5. (Continued)

Investment from Other Grants				
Highways and Streets	Emergency Public Works	All Other	Subtotal	Total Investment from Federal Capital Grants
1,847	21	88	1,956	2,108
10,631	0	704	11,335	12,051
11,014	4	1,939	12,957	16,141
11,579	1	1,826	13,407	18,429
11,695	0	1,679	13,374	19,471
10,553	0	1,580	12,133	18,793
8,898	0	1,518	10,416	17,461
8,248	0	1,664	9,912	18,958
7,666	0	1,411	9,077	18,271
9,038	216	1,401	10,655	21,805
8,879	1,780	1,337	11,996	24,801
8,325	3,780	1,069	13,174	25,692
8,417	1,730	1,015	11,162	24,671
8,813	380	889	10,082	24,607
8,496	77	798	9,371	22,711
7,971	30	627	8,628	20,201
9,014	0	813	9,827	20,308
10,500	1	924	11,425	22,007
11,382	0	982	12,364	22,902
12,254	0	935	13,188	22,932

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